DEVELOPING A CLINICAL PATHWAY FOR THE EXTUBATION OF A MECHANICALLY VENTILATED PAEDIATRIC PATIENT IN A PRIVATE HOSPITAL IN GAUTENG

BY

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DECLARATION

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I, Marinda du Plessis, hereby declare that the following study, ***Developing a clinical pathway for the extubation of a mechanically ventilated paediatric patient in a private hospital in Gauteng***, is my own work. I further declare that all sources used have been acknowledged by means of a complete reference list and indicated throughout the text. This work has not been submitted for any other degree or at another institution.

___________________ ____________________

Marinda du Plessis Date

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ABSTRACT

On a daily basis critically ill paediatric patients are admitted in the Paediatric Critical Care Unit (PCCU). Some of these paediatric patients require cardiothoracic surgery and is mechanically ventilated post-operatively.

Chapter one of this study gives an orientation to this research and explains that in order to prevent ventilator associated complications and high hospitalisation costs, the mechanically ventilated paediatric patient following cardiothoracic surgery should be extubated as soon as he/she is ready. Chapter two is dedicated to the available literature on this topic and indicates that literature on extubation criteria for the mechanically ventilated paediatric patient is minimal. The methodology of this study is discussed in detail in Chapter three. Chapter four gives a detailed explanation of the research findings and the researcher included the developed clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery in a private hospital in Gauteng. The relevant clinical pathway functions as a guideline and evidence-based tool in the PCCU. Lastly Chapter five gives a summary of this study and a few recommendations are made. The researcher has included a personal reflection in this Chapter.

Keywords:

Cardiothoracic surgery; clinical pathway; congenital heart disease; extubation criteria; mechanical ventilation; paediatric patient.

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1 OVERVIEW OF THE STUDY

"Science is the father of knowledge, but opinion breeds ignorance"

-Hippocrates-

1.1 INTRODUCTION

The nursing profession is based on a specialised body of knowledge that reflects different philosophies and views about the phenomena which are of interest to the nursing profession (Hufft, n.d.:17). Even in modern times paediatric critical care medicine can be regarded as a *new* speciality (Hita, 2011:328).

Critically ill paediatric patients are admitted to the Paediatric Critical Care Unit (PCCU) on a daily basis. Critically ill children include paediatric patients with congenital cardiac conditions such as ventricular septal defects (VSD), atrial septal defects (ASD) and tetralogy of Fallot and who are in need of cardiothoracic surgery. These paediatric patients require cardiac surgery and are mechanically ventilated post-operatively. According to Shi, Zhao, Zheng, Liu, Shu, Tan, Lin, Shi and Fang (2008:768), there is a growing population of paediatric patients who undergo complex surgery and therefore require post-operative critical care (refer to Section 2.2). On doctors' request these mechanically ventilated paediatric patients are extubated by the critical care registered nurses in the PCCU on a daily basis; however, in the specific PCCU extubation criteria for the paediatric patient does not exist.

Yoder-Wise (2003:183) opines that the multidisciplinary team members should co-construct and reach consensus on accepted standards of care and practice whenever possible. For the PCCU, this implicates that the multidisciplinary team members involved in the management of the mechanically ventilated paediatric patient should agree on the sequence of events when considering extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery. In view of Yoder-Wise (2003:81) collaborative decisions are more likely to result if the multidisciplinary team member's involvement in problem-solving and decision-making processes.

A multidisciplinary approach is essential and specialists should agree on the sequence of events when considering extubation of the mechanically ventilated paediatric patient (Venkataraman, 2006:155).

Chavez, dela Cruz and Zaritsky (2006:324) state that a significant contribution to paediatric patient care will be a collaboratively developed clinical pathway for the extubation of the mechanically ventilated paediatric patient. Feuth and Claes (2008:56) describe a clinical pathway as a tool for improving clinical processes. The construction of a clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery may positively contribute to the quality of care provided to these patients by the multidisciplinary team members. It is the opinion of BouAki (2012:44) that weaning and extubation protocols comprise the following three components: i) a list of criteria to assess readiness to wean, ii) guidelines to reduce ventilatory support, and iii) a list of criteria to extubate the mechanically ventilated patient. Sánchez (2008:78) states a clinical pathway defines when, how and in what sequence patient care should be given.

The purpose of a clinical pathway is to improve the coordination and continuity of care, including the different disciplines and specialties (Salter, 2005:27). As stated by Lombardo, Bridgeman, De Michelis and Nunez (2008:46), the benefits to the healthcare system utilising the continuum concept lies in the increase of the quality of healthcare provided. Morss, Garg, Nyberg, Dawson, Pronovost, Morlock, Rubin, Diener-West and Wu (2003:637) emphasise that clinical pathways are used in an attempt to reduce the patient's length of stay in hospital thereby decreasing hospitalisation costs. The purpose of this study was to develop a clinical pathway for the extubation of a mechanically ventilated paediatric patient following cardiothoracic surgery in a private hospital in Gauteng.

1.2 BACKGROUND

The paediatric patient is viewed by Schwenzer (2008:1343) as a "vulnerable subject" because they have undeveloped decision-making skills; the author's statement thus emphasises the gravity of providing the appropriate and optimal care for the paediatric patients in the PCCU.

Schmitt and Gausche-Hill (2011:9) highlights that it is important to recognise that the paediatric patient differs anatomically, physiologically and emotionally from the adult patient. In addition, the types of illnesses and injuries the paediatric patients sustain and their responses to it vary across the paediatric age span (Pollak, 2008:415). In Bachrach's (2004:924) view, due to these significant physiological differences it is potentially dangerous for the paediatric patients if it is simply assumed by the members of the multidisciplinary team, that they will have the same responses to disease or therapy as adult patients. For these reasons the multidisciplinary team members involved in the management of the mechanically ventilated paediatric patient following cardiothoracic surgery have to tailor the management approaches (clinical pathway) to accommodate the differences in care.

Critically ill or injured paediatric patients are nursed in the PCCUs. Many of them require mechanical ventilator support to maintain alveolar ventilation or exchange gas between the lungs and the ambient air by causing air to flow in and out of the lungs via changing airway pressures (Holleran, Rouse & Carpenter, 2009:160) (refer to Section 1.8.6.4). Mechanical ventilation is one of the management strategies utilised in the PCCU; unfortunately though it can also lead to various complications such as barotrauma, acute lung injury, mucus plugs, the displacement of the endotracheal tube, pulmonary infections, sepsis, and a lack of humidification (Holleran, et al., 2009:168; Moniz, Silvestre, Nunes, Abadesso, Matias, Loureiro & Almeida, 2013:49). Additional hospitalisation costs can be incurred if complications arise; moreover, it may also result in an increase in the morbidity and mortality of paediatric patients. This view is supported by Lombardo et al. (2008:45) and Shi et al. (2008:768) by stating the increase in health-care costs and prolonged mechanical ventilation has been associated with an increase in morbidity and mortality. To prevent or limit the aforementioned complications it is crucial for the mechanically ventilated paediatric patient following cardiothoracic surgery to be extubated as soon as possible.

According to Cooper, Costello, Bronicki, Stock, Jacobs, Ravishankar, Dominguez and Ghanayem (2008:81), there are several advantages to early extubation, namely a decrease in ventilator-associated nosocomial infections, a shorter stay in the PCCU, and less hospital costs. BouAki, Bou-Khalil, Kanazi, Ayoub, and El-Khatib (2012:42) have an alternative view as regarding to early extubation. These authors posit that, if the patient is extubated too early, the paediatric patient is exposed to extubation failure and re-intubation.

In the PCCU the multidisciplinary team members responsible for the management of the critically ill or injured paediatric patient consist of paediatricians, critical care registered nurses, and physiotherapists. A multidisciplinary team is defined as "a partnership among healthcare workers" of different disciplines inside and outside the health sector with the singular goal of providing quality, comprehensive and efficient health services (International Association of Physicians in AIDS care, 2011:1). Another definition for a multidisciplinary team is provided by the Royal Australian College of General Practitioners (2011:453) states a multidisciplinary team consists of professionals from a range of disciplines that renders comprehensive health care comprising different but complementary skills, knowledge and experience.

The process of deciding when to extubate the mechanically ventilated paediatric patient following cardiothoracic surgery starts the moment endotracheal intubation is done. The problematic issue, however, is that no international criteria exist in order to guide the multidisciplinary team members whether the mechanically ventilated paediatric patient ought to be extubated or not (Farias & Monteverde, 2006:322; Stawicki, 2007:13; CIGNA, 2008:8). This global uncertainty might be the reason why the extubation criteria for the mechanically ventilated paediatric patient, as observed by the researcher in the PCCU in the private hospital in Gauteng where the study was conducted, were not clearly defined. This is consistent with the view of Stawicki (2007:13) who state "the science of determining if the patient is ready for extubation is still very imprecise". According to Mhanna, Anderson, Iyer and Baumann (2013:np.) paediatric literature on extubation criteria are limited.

According to Maung and Kaplan (2012:15), the optimal method for determining when the mechanically ventilated patient is ready for extubation has been studied extensively over the years. Extubation involves the removal of the endotracheal tube after the weaning process (refer to Section 1.8.6.3). As already mentioned the mechanically ventilated paediatric patient should be extubated as soon as possible in order to avoid complications. The researcher will facilitate a collaborative effort to develop a clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery.

1.3 PROBLEM STATEMENT

In the PCCU setting of this study, there is a lack of concurrence between the different multidisciplinary team members (paediatricians, cardiothoracic surgeon, cardiologist and registered nurses) regarding the sequence of events and criteria for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery. The following quotes from the critical care registered nurses in the specific PCCU support this statement:

"... I just do what I am told..."
"... I must act on what the doctor says..."
"... I don't agree ... patients remain intubated for days..."
"...The multidisciplinary team members cannot agree when to extubate..."

The above mentioned quotations of critical care registered nurses effectuated the current research study conducted in the PCCU in a private hospital in Gauteng. In this particular PCCU many paediatric patients required cardiac surgery and were mechanically ventilated post-operatively (refer to Table 1.1). As stated in Section 1.2 several complications are associated with prolonged mechanical ventilation. To avoid these complications the extubation of the mechanically ventilated paediatric patient should be undertaken as soon as the patient complies with the extubation criteria.

The multidisciplinary team members in the PCCU disagree on the appropriate timing of extubation. This disagreement is a problematic issue since it can cause a decrease in quality patient care thereby increasing the risk of complications as well as a rise in hospitalisation costs. If consensus on the sequence of events for extubation of the mechanically ventilated paediatric patient is not reached, it may result in dispute and a negative working environment which can, in turn lead, to job dissatisfaction. Roelen, Koopmans and Groothoff (2008:433) confirms this statement by indicating that many factors such as professional status, cohesion with colleagues, collaboration with the staff and the strength of the organisational culture have been associated with job satisfaction. It is the opinion of Wadhwa, Daljeet, Singh, Verghese, Manoj, Wadhwa, Dalvinder and Singh (2011:109) that the work environment should allow the employee to do her or his job properly. Satisfied employees play a crucial role in the health organisation's success (Parvin & Kabir 2011:119; Lorber & Savič, 2012:263).

As stated by Muller (2002:187), conflict can be destructive, leading to inadequate task performance and causing a decrease in the quality of nursing care. Furthermore, Chan and Huak (2004:207) are of the opinion that the lack of clear direction and participation in the healthcare setting leave employees feeling isolated, pressured and frustrated. Yoder-Wise (2003:21) is of the opinion that the critical care registered nurses are less likely to function at their optimum level if they do not experience a favourable working environment. Hughes (2008:7) further points out that the work environment can have an impact on the safety and quality of the healthcare provided. Obviously this situation can have a negative impact on the paediatric patient and his or her family members. Multidisciplinary team members should agree on the extubation criteria of the mechanically ventilated paediatric patient following cardiothoracic surgery in order to avoid complications and job dissatisfaction. A possible solution to the problem of reaching consensus on this issue could be for the multidisciplinary team to engage in a collaborative effort towards the development of a clinical pathway for the extubation of the mechanically ventilated paediatric patient (refer to Section 2.4).

1.4 RESEARCH QUESTION

The following research question emerged from the background and problem statement:

"Which components should be included in a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery?"

1.5 AIM AND OBJECTIVES

The aim of this study was to develop a clinical pathway for the extubation of a paediatric patient following cardiothoracic surgery in a private hospital in Gauteng. In order to achieve this aim the objectives were to:

- explore the components of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery

- compile a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery

1.6 SCOPE AND LIMITATIONS OF THE STUDY

The scope of this research study included the paediatric patient in the PCCU who required cardiothoracic surgery and mechanically ventilated post-operatively. As stated in Sections 1.2 and 1.3, prolonged mechanical ventilation poses several complications which can be avoided with early extubation of the mechanically ventilated paediatric patient.

Cardiothoracic surgery is required when the paediatric patient presents with congenital heart disease (view Section 1.1). Shi et al. (2008:768) opine that there is an increasing number of paediatric patients requiring cardiothoracic surgery who subsequently need post-operative critical care (refer to Section 2.2). These paediatric patients are mechanically ventilated post-operatively. As stated by Shi et al. (2008:768) the duration of mechanical ventilation correlates with post-operative morbidity and mortality.

Extubation refers to the removal of the endotracheal tube of the mechanically ventilated paediatric patient (refer to Section 1.8.6.3) but, as mentioned in Section 1.2, the criteria for the extubation of the mechanically ventilated paediatric patient are vague and undefined. Thus, the purpose of this study was to develop a clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery.

The only limitation identified by the researcher had to be taken into consideration during the execution of this study. This study was conducted in a private, Level 3 hospital (refer to Section 1.8.1). Hence, the study was not necessarily applicable to the government sector due to differences in structures, resources, protocols and regulations.

1.7 SIGNIFICANCE OF THE STUDY

This study was built on the available literature as regards the extubation criteria of the mechanically ventilated paediatric patient following cardiothoracic surgery. The researcher envisaged that, by using evidence-based information, this study would alter, complement and improve the practice applied in the relevant PCCU at the time the study was done. Evidence-based medicine is the process of integrating individual clinical expertise with the best available clinical evidence from systematic research (Pai, McCulloch, Pai, Enanoria, Kennedy, Tharyan, Prathap & Colford, 2004:86). Delivering evidence-based care improves quality patient care and patient satisfaction. According to Cheng, Huang, and Lin (2012:617), improving the quality of patient care is the main priority in the healthcare industry. Indeed, delivering quality patient care enhances patient outcomes.

The nursing profession is a dynamic discipline which requires continuous personal and professional development. The researcher believed this study would aid the process of personal and professional development not only in her but also in the critical care registered nurses. The benefits for the multidisciplinary team members would include gaining valuable information on the extubation criteria of the mechanically ventilated paediatric patient following cardiothoracic surgery. The collaborative process of developing a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery will enhance teamwork and buy in from the participants in this study. Since clinical pathways are not widely utilised in South Africa, it was perceived that this study would contribute positively to the introduction and development of clinical pathways (refer to Section 2.4).

1.8 RESEARCHER'S FRAME OF REFERENCE

The frame of reference of this study is described in terms of the setting, the role of the researcher, the relevant paradigm, conceptual framework and conceptual definitions.

1.8.1 Setting

This study was conducted in a private hospital in Gauteng, South Africa. It is a Level 3 hospital with a total of 470 beds at the time the study was conducted. A Level 3 hospital provides a highly specialised level of surgical and medical care to patients (Duma, de Swardt, Khanyile, Kyriacos, Mtshali, Maree, Puoane, van den Heever & Hewett 2008:102). This specific hospital has a range of specialists and equipment available 24 hours a day. It provides 24-hour-service to patients of all ages. There are two high care units, namely general high care and neurovascular high care and five critical care units, namely PCCU, Neonatal, Multi, Trauma and Cardiac Critical Care Units.

At the time the study was conducted the PCCU had eight beds. The majority of children admitted to the PCCU were critically ill due to an underlying medical condition or they required cardiothoracic surgery. The multidisciplinary team members involved in the PCCU included nine critical care trained registered nurses and nine registered nurses (referred to in this study as paediatric nurses), six paediatricians, two neurosurgeons, one neurologist, two cardiologists, two cardiothoracic surgeons and three physiotherapists. In Table 1.1 a summary of the cardiothoracic admissions (mechanically ventilated) in the PCCU, from July 2011 to June 2012, is provided. The table was compiled from the relevant hospital statistics.

In Table 1.1 the researcher summarised the total admissions and the number of cardiothoracic surgery patients admitted in the PCCU. The number of children for atrial septal defects (ASD), ventricular septal defects (VSD) or tetralogy of Fallot that were corrected surgically are shown. Other congenital heart defects such as aortic valve and coartation of the aorta repairs are indicated under the last column in Table 1.1. Several of the cardiothoracic surgeries included the repair of more than one defect as indicated in the months of November 2011 and February 2012.

Table 1.1: Summary of admissions in PCCU

Date (July 2011- June 2012)	Total admitted in PCCU	Total cardio-thorac Surgery	Atrial septal defects (ASD)	Ventri cular septal defects (VSD)	Tetralogy of Fallot	Other cardio-thorac Surgery
July 2011	30	3	0	1	0	2
Aug 2011	33	1	0	0	0	1
Sept 2011	21	3	1	0	1	1
Oct 2011	21	2	0	0	0	2
Nov 2011	23	8	3	4	0	3
Dec 2011	31	0	0	0	0	0
Jan 2012	21	0	0	0	0	0
Feb 2012	29	4	1	0	1	4
Mar 2012	26	1	0	0	0	1
April 2012	27	4	2	0	0	2
May 2012	20	1	0	0	0	1
June 2012	27	7	1	1	0	6
Total	**309**	**34 (11%)**	**8 (23%)**	**6 (8%)**	**2 (6%)**	**22 (65%)**

(Hospital statistic:2011-2012)

1.8.2 Role of the researcher

In the view of Creswell (2003:184), qualitative research is interpretive research where the researcher is typically involved in a sustained and intensive experience with the study participants. During qualitative research the researcher is considered as the instrument for data collection and data analysis (Driessnack, Sousa & Mendes, 2007:685). Qualitative researchers should explicitly identify their biases, values and personal interests about their research topic and the research process. In the current study it was done throughout the research process and enhanced by utilising an independent coder as well as experienced supervisors. Also, the assumptions (refer to Section 1.8.4) were delineated and consensus was reached on specific ground rules which formed the basis of the discussions during the workshop.

The four elements of the researcher's role as identified by Creswell (2003:184) were stringently applied during the current study. Firstly, the statements included related to past experiences and provided the background data for the audience to better understand the topic, the setting and the study participants (refer to Section 1.3). Secondly, the steps which needed to be taken to gain access (refer to Section 1.9.2) to the research setting and to secure permission (refer to Annexure A) to conduct the study were adhered to. Thirdly, comments on connections between the researcher and the study participants with regard to the research setting were indicated (refer to Section 1.9.2) and finally, comments regarding ethical issues were documented (refer to Section 1.11).

1.8.3 Paradigm

According to Polit and Beck (2006:506), a paradigm is a way of looking at a natural phenomenon which then guides the researcher's approach to the inquiry. The phenomenon concerned with in this study was the components of a clinical pathway for the extubation of a mechanically ventilated paediatric patient following cardiothoracic surgery. A paradigm is further described as a model, pattern or standard (Waite, 2006:597). Toloie-Eshlaghy, Chitsaz, Karimian and Charkhehi

(2011:108) define a paradigm as “a set of hypotheses to determine the thinking mode of the researcher”.

The paradigm used in this study was constructivism. Polit and Beck (2006:15) define the constructivist paradigm as “a reality that is not a fixed entity, but rather a construction of the individuals participating in the research”. For the purpose of this study the researcher facilitated a workshop with study participants as part of the data collection process (refer to Section 3.3.3). In the constructivism paradigm reality does not exist; knowledge is constructed through the research process and interpreted through the researcher’s own values and assumptions (Reynolds, Kizito, Ezumah, Mangesho, Allen & Chandler, 2011:4). Constructivism is further defined by Glaser (2012:35) as a means of seeking meaning from the study participants’ and the researcher’s explanations.

Since the constructivist paradigm is cemented in the belief that knowledge is maximised when the distance between the researcher and the study participants is minimised, the researcher was actively part of the research process and interacted with the study participants throughout the research process. The researcher facilitated a workshop with eight critical care registered nurses and one physiotherapist and was thus actively involved in the research process.

1.8.4 Assumptions

According to Polit and Beck (2008:748), an assumption is “a principle that is accepted as being true based on logic or reason, but without proof’. The paradigms of human inquiry are mostly categorised according to “the ways they respond to the basic philosophical questions” (Polit and Beck, 2008:13). In Table 1.2 the specific assumptions related to this study are outlined.

Table 1.2: Summary of the assumptions

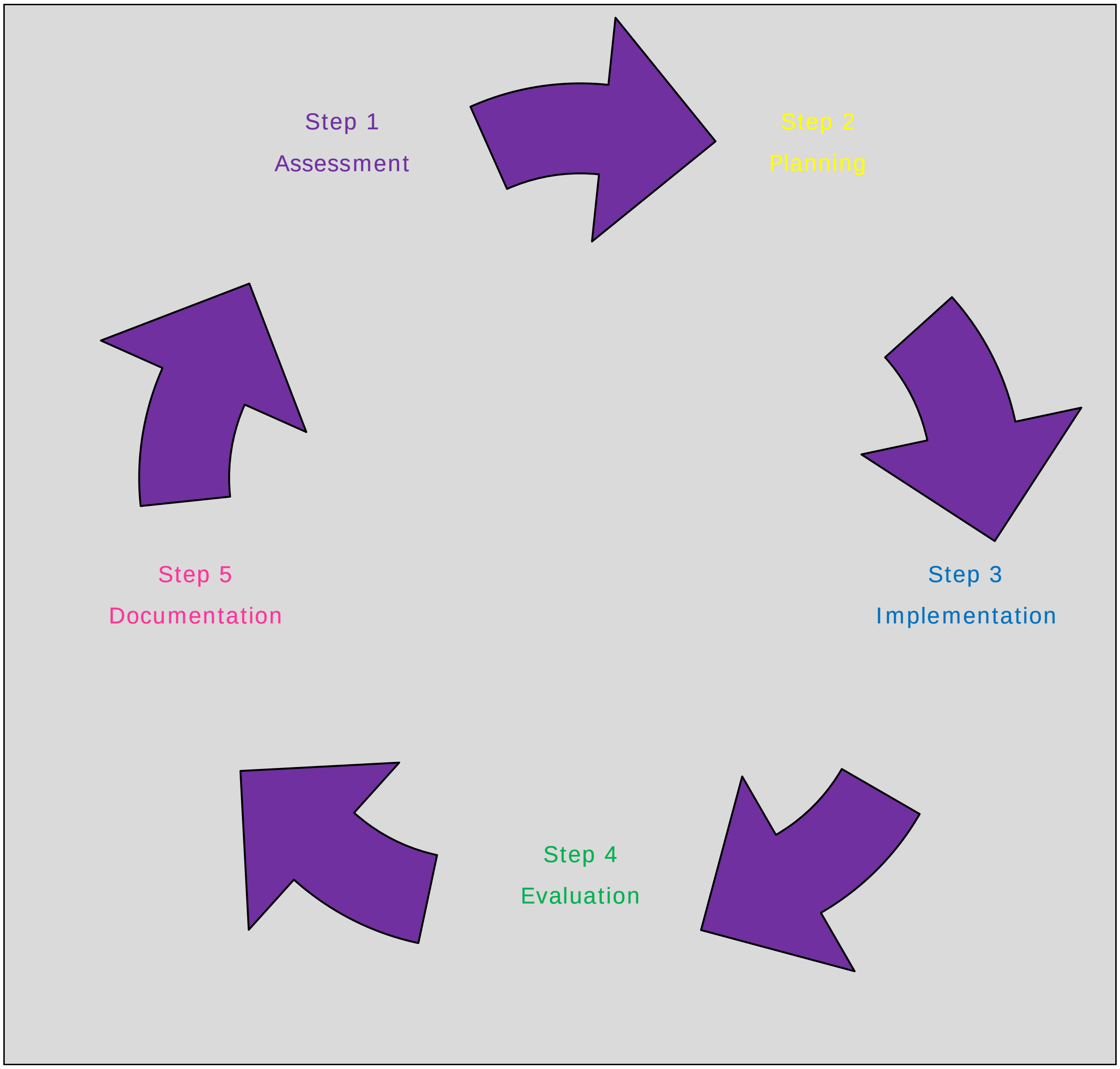
Assumption	Application
Ontological: What is the nature of reality?	• Reality is multiple and subjective • Reality is mentally constructed by individuals based on their knowledge and experience • Members of the multidisciplinary team collaboratively developed a clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery
Epistemological: How is the inquirer related to those being studied?	• The researcher interacted with members of the multidisciplinary team • The researcher is a critical care registered nurse who acted as a colleague and was part of the multidisciplinary team
Methodological: How is evidence best obtained?	• Context bound and contextualised. The context was a specific PCCU in a Level 3 hospital in Gauteng • The methodology was an inductive and emergent design with qualitative data analysis • The aim of the research was to improve the outcomes of mechanically ventilated paediatric patients following cardiothoracic surgery. Collaboration was obtained from the multidisciplinary team members who had experiences in the extubation of paediatric patients as well as a complete literature review was done

(Adopted from Polit and Beck, 2008:14)

1.8.5 Conceptual framework

A conceptual framework is the overall conceptual underpinnings of a study (Polit and Beck, 2008:142). It is the opinion of Hufft (n.d.:19) that a conceptual framework provides a structure by which a discipline can be understood in terms of theoretical methods and assumptions. The nursing process was utilised as the conceptual framework to guide the current study as suggested by Barnes Bolander (1994:110-

111), Potter and Perry (1997:105) and Yildirim and Őzkahraman (2011:258). The nursing process comprised of five steps and was utilized as the conceptual framework in this study.



(*Adopted from Potter and Perry, 1997:105*)

Figure 1.1: **The nursing process**

According to Barnes Bolander (1994:110), a process is "a series of planned steps and methods that produce particular results". The nursing process is a problem-solving approach for meeting health care needs of paediatric patients (Smeltzer & Bare, 2004:34; Yildirim & Őzkahraman, 2011:258) and is used every day in the clinical practice to assist with improving the outcomes of patient care. Reeves and Paul (2002:21) state the nursing process provides a thinking/doing approach to the rendering of nursing care. A clinical pathway can be constructed in a similar manner as the nursing process.

For the purpose of this study, the nursing process was used as the conceptual framework to guide the study participants in developing a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery. This meant that the nursing process guided the questions asked during the data collection to ensure that all the components of the nursing process were included. Each of these components is discussed with special attention paid to its application during the development of the clinical pathway. In Figure 1.1 the five steps of the nursing process is illustrated. Each of the steps of the nursing process will be discussed in Sections 1.8.5.1-1.8.5.5.

1.8.5.1 Assessment

The first step in the nursing process is assessment. According to Dreyer, Hattingh and Lock (1997:16), assessment can be regarded as the most important step in the nursing process. It entails the gathering of information in an orderly manner after which it is sorted and organised (Booyens, 1999:205). Geyer, Mogotlane and Young (2011:193) define assessment "as the gathering of information relevant to the patient". Assessment is the ordered collection and analysis of data for the purpose of making a nursing diagnosis (Reeves & Paul, 2002:25). The Anonymous: Nursing process NS 09.1 (2009:1) indicates that assessment entails the identification of the patient's health status and needs. Using the nursing process, the mechanically ventilated paediatric patient following cardiothoracic surgery should first be assessed to determine whether extubation is indicated (refer to Section 4.3).

1.8.5.2 Planning

Planning is the second component of the nursing process. Planning involves the formulation of specific goals and the identification of actions to be implemented. Dreyer et al. (1997:18) explain planning as a logical, systematic, decision-making process while Reeves and Paul (2002:31) add the planning process reflects the nursing actions. It is the opinion of Geyer et al. (2011:202) that planning determines the nursing actions to be taken; this would thus include determining outcomes, nursing interventions, decisions on equipment and methods to be used in order to meet the identified needs of the patient (refer to Section 4.4).

1.8.5.3 Implementation

The purpose of the implementation component of the nursing process is to perform the planned actions (Sundeen, Stuart, Rankin & Cohen, 1998:18). According to Geyer et al. (2011:205), the implementation step involves the implementation of the care plan in the clinical situation. Dreyer et al. (1997:19) hold that the first task during implementation is to identify the knowledge and skills needed to implement the plan and to whom the responsibility will be delegated. In other words, as Reeves and Paul (2002:32) simply put it, implementation is putting the plan into action. The clinical pathway should indicate the sequence of events that should be implemented during extubation of the paediatric patient following cardiothoracic surgery.

1.8.5.4 Evaluation

The final component of the nursing process is evaluation. This component involves the assessment of the patient’s response to nursing care (Geyer, et al., 2011:206). According to Hogston (2006:19), the evaluation component of the nursing process serves to ascertain whether set goals were achieved and is an opportunity to evaluate the nursing interventions. Evaluation can be regarded as an act of appraisal (Dreyer, et al., 1997:20). It is further stated by Geyer et al. (2011:206) that the evaluation of the care plan is a systematic, criterion-based and ongoing process (refer to Section 4.6).

1.8.5.5 Documentation

Documentation forms an integral part of the health care system and is an essential instrument (Dreyer, et al., 1997:21; Geyer, et al., 2011:207). Documentation serves as a means of communication and is an ongoing activity which starts in the first step of assessment, and continues through all the other steps of the nursing process (Dreyer, et al., 1997:21-22). A favourite saying in nursing is: "If it was not documented, it was not done" (T.J.J., n.d.).

1.8.6 Classification of key terms

For simplicity and consistency throughout, the key terms used in the context of this study were defined and are presented next.

1.8.6.1 Cardiothoracic surgery

Cardiothoracic surgery is required when the paediatric patient presents with congenital heart disease. According to Martin (2010:115), the cardiovascular system can be defined as the heart with two networks of blood vessels. The term *thorax* refers to the part of the body cavity between the neck and the diaphragm (Martin, 2010:728). Martin (2010:709) further explains the term *surgery* is defined as the "branch of medicine that treats injuries, deformities or disease by operation or manipulation". For the purpose of this study, the term *cardiothoracic surgery* referred to surgery to correct congenital heart disease in the paediatric patient (refer to Section 2.2).

1.8.6.2 Clinical pathway

Feuth and Claes (2008:56) describe *clinical pathways* as "optimal care processes, sequencing and timing of interventions by healthcare professionals for a particular diagnosis or procedure". They emphasise that the clinical pathway may be utilised as a strategy for improving patient care in the clinical setting.

Clinical pathways are also referred to as critical pathways or care pathways (Marquis & Huston, 2006:228). Muscholl (2005:1) emphasises that a clinical pathway is a multidisciplinary plan which should aim for "best clinical practice for a homogeneous group of medical cases". In the opinion of Rose, Nelson, Johnston and Presneill (2007:435) protocols implemented by the multidisciplinary team members can reduce the duration of mechanical ventilation and weaning. For the purpose of this study, a clinical pathway was defined as the sequence of events that mapped the actions that should be followed when extubating a paediatric patient following cardiothoracic surgery in the PCCU and which has been collaboratively developed by the multidisciplinary team (refer to Section 2.4).

1.8.6.3 Extubation

Farias and Monteverde (2006:322), Venkataraman (2006:155) and Stawicki (2007:13) are in agreement that *extubation* is the removal of an endotracheal tube in the mechanically ventilated patient. In the relevant PCCU, many of the critically ill paediatric patients following cardiothoracic surgery were intubated and mechanically ventilated. To avoid complications, these patients should be weaned from mechanical ventilation and extubated as soon as possible. For the purpose of this study extubation referred to the removal of an endotracheal tube in the mechanically ventilated paediatric patient following cardiothoracic surgery (refer to Section 2.3.6 and Section 4.6).

1.8.6.4 Mechanical ventilation

Waite (2006:525) states *mechanical* indicates a mechanical device and *to ventilate* is to oxygenate (Waite, 2006:895). "Movement of air in and out of the airways" is another definition for ventilation (Smeltzer & Bare, 1996:433). A mechanical ventilator is a breathing device that can maintain ventilation and oxygen delivery for a prolonged period (Smeltzer & Bare, 1996:555). Maung and Kaplan (2012:23) explain that *mechanical ventilati*on is a complex intervention with a wide variety of components. The purpose of mechanical ventilation is to provide adequate oxygenation, carbon dioxide (CO_2) clearance and the management of the work of breathing (Maung & Kaplan, 2012:3). For the purpose of this study mechanical ventilation referred to the mechanical process whereby a ventilator is used to move air in and out of the lungs of the intubated paediatric patient following cardiothoracic surgery (refer to Section 1.2).

1.8.6.5 Multidisciplinary team

A *multidisciplinary team* can be defined as the partnership among healthcare workers of different disciplines inside and outside the health sector with the aim to provide quality, comprehensive and efficient health services (International Association of Physicians in AIDS care, 2011:1). Martin (2010:474) defines the multidisciplinary team as "a group of health care professionals with different areas of expertise who unite to plan and carry out treatment of complex medical conditions". The Royal Australian College of General Practitioners (2011:453) defines a multidisciplinary team as comprehensive health care that is provided by professionals from a range of disciplines with different but complementary skills, knowledge and experience (refer to Section 1.2). In this study the multidisciplinary team referred to a team of health care professionals (eight critical care registered nurses, one physiotherapist, one anaesthetist, one anaesthetist/intensivist and two paediatricians) with comprehensive health care knowledge and skills, which complement each other in caring for the critically ill paediatric patient.

1.8.6.6 Paediatric critical care unit (PCCU)

Stanton and Behrman (2007:1) state *paediatrics* is concerned with the health of infants, children, and adolescents, their growth and development. The paediatric critical care unit (PCCU) is a specialised environment (Potts & Mandleco, 2007:481). It is important to note that the paediatric patient differs anatomically, physiologically and emotionally from the adult patient (Schmitt & Gausche-Hill, 2011:9). For the purpose of this study the *paediatric critical care unit* (PCCU) was the dedicated critical care unit in a private hospital in Gauteng specialising in the management, care and mechanical ventilation of the paediatric patient following cardiothoracic surgery.

1.8.6.7 Paediatric patient

Paediatrics is the "study of growth and development of the child from the moment of conception through to adolescence" (Coovadia & Wittenberg, 1998:3). In order to obtain a definition for the paediatric patient the researcher found several sources classifying the age span of a paediatric patient. However, she [the researcher] discovered there were several contradictions in literature regarding the age span of a paediatric patient. These different age classifications are tabulated in Table 1.3. In Table 1.3 the researcher indicated the differences in the paediatric age span as discovered in various literature sources.

Table 1.3: Age classifications of the paediatric patient

Classification of the paediatric patient	Age according to Sanders and Robinson (2012)	Age according to Geyer et al. (2011)	Age according to Emergency Medical Services Authority (EMSA) (2011)	Age according to Riffeē and Wharton (n.d.)
Neonate	Birth to 27 days of life	Birth to 28 days of life	Birth to 28 days of life	Birth to one (1) month
Infant	28 days to 23 months	1 month to 12 months	Neonatal period up to 12 months	1 month to 12 months
Toddler	No classification	1 to 3 years	1 to 3 years	1 to 5 years
Pre-school/Child	2 to 11 years	3 to 6 years	4 to 5 years	No classification
School-age/Child	No classification	6 to 12 years	6 to 10 years	6 to 12 years
Adolescent	12 to 18 years	12 to 20 years	11 to 14 years	13 to17 years

(Adopted from Geyer et al., 2011:17; EMSA, 2011:1; Sanders & Robinson, 2012:7; Riffeé & Wharton, n.d.:2).

For the purpose of this study the paediatric patient was defined as a mechanically ventilated child between 28 days to 12 years old (refer to Table 1.3).

1.9 RESEARCH DESIGN

Polit and Beck (2006:504) describe and define the research method as the "steps, procedures and strategies for gathering and analysing data in a research investigation". The research method consists of the research design and methodology which are discussed in detail in Chapter 3.

The research design is defined as "the overall plan for obtaining answers to the questions being studied and for handling some of the difficulties encountered during the research process" (Polit & Beck, 2008:66). In other words, the study design describes how the study will be conducted. According to Strőmberg (n.d.:n.p.), the study design includes a description of participant selection and the setting of the study. Yin (2011:75) states the study design serves as the "logical" plan according to which a research study is conducted. In the current study a qualitative, contextual, explorative and descriptive design was utilised.

1.9.1 Qualitative design

In qualitative research the study design typically evolves over the course of the project (Polit & Beck, 2008:219). Yin (2011:8) holds that qualitative research has the ability to represent the views and perspectives of the study participants and it covers contextual conditions (refer to Section 1.9.2). According to Polit and Beck (2008:763), qualitative research is "the investigation of phenomena, typically in an in-depth and holistic fashion, through the collection of rich narrative materials using a flexible research design". In this study the phenomenon under investigation was the components of a clinical pathway for the extubation of the mechanically paediatric patient following cardiothoracic surgery. Polit and Beck (2008:219) further state a qualitative design involves the combination of various data collection strategies, which in this study included a literature control, a workshop and field notes. In addition, Polit and Beck (2008:219) ascertain that during a qualitative study the researcher is required to become the research instrument. In this study the researcher was involved in the data collection, interpretation of the findings and in the writing of the final report. Refer to Section 3.2.1 for more information on the qualitative design.

1.9.2 Contextual design

The context is to describe and understand events within the natural setting in which they occur (Babbie & Mouton, 2001:272). This study was done in a holistic, contextual manner and the aspects related to the why, how and when of the execution thereof were addressed. Strőmberg (n.d.:n.p.) explains the setting includes where the data are collected, a description of the sample, and whether non-participants are present during the data collection process. The context for the current study was a PCCU in a private hospital in Gauteng, South Africa. The unit consisted of eight beds and children from infancy (28 days) to 12 years of age were admitted. Cardiothoracic and medical patients made up the majority of paediatric patients in the PCCU. In Section 3.2.2 more in-depth detail is provided on the contextual design.

1.9.3 Explorative design

Exploratory research begins with a phenomenon of interest (Polit & Beck, 2008:20). Exploratory studies are aimed at obtaining in depth insight and a better understanding of phenomenon by investigating the full nature of it in the research study (Uys & Basson, 1998:38). The researcher explored the components that should be included in the development of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery in the current study (in Section 3.2.3 a thorough explanation of the explorative design is given). The nursing process was utilised as conceptual framework to guide the questions used during the data collection process (refer to Section 1.8.5).

1.9.4 Descriptive design

Qualitative researchers describe the dimensions, variations, and importance of a phenomenon (Polit & Beck, 2008:19). In view of Uys and Basson (1998:38), the researcher describes “that which is” during the descriptive design. (Refer to Section 3.2.4). The various components of the phenomenon investigated in this study were described in order to develop a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery in a private hospital in Gauteng. It was deemed essential to investigate the phenomenon to improve nursing practice and the overall quality of paediatric patient care.

1.10 RESEARCH METHOD

Henning, van Rensburg and Smit (2004:36) state that the term *methodology* refers to the coherent group of methods that complement one another to deliver data and findings that will reflect the research. The research methodology includes the specific process for conducting the study (Burns & Grove, 2009:719). Table 1.4 provides a summary of the research method.

Table 1.4: Summary of the research method

Phase 1: Components of the clinical pathway				
Population	**Sampling**	**Data collection**	**Data analysis**	**Trust-Worthiness**
Members of the multidisciplinary team: • Critical care registered nurses • physiotherapist	• Purposive sampling • Sample size: nine participants (eight critical care registered nurses and one physio-therapist)	Workshop: • written notes from the study participants • field notes	• Content analysis	• Credibility • Dependability • Confirmability • Transferability • Authenticity
Phase 2: Literature control				

Phase 3: Validation phase				
Population	**Sampling**	**Data collection**	**Data analysis**	**Trust-worthiness**
Experts/specialists	• Purposive sampling • Sample size: seven participants (one anaesthetist, one anaesthetist/ intensivist and two paedia-tricians)	Written feedback on draft clinical pathway	• Content analysis	• Credibility • Dependability • Confirmability • Transferability • Authenticity

Table 1.4 indicates the population, sampling, data collection and data analysis in the two phases of the research method. The components of trustworthiness in both phases are also indicated. The research method is discussed in detail in Chapter 3.

1.11 ETHICAL CONSIDERATIONS

Ethics is defined as "a system of moral values that is concerned with the degree to which research procedures adhere to professional, legal, and social obligations to the study participants" (Polit & Beck, 2008:753). The conduct of research requires not only expertise and diligence, but also a high degree of honesty and integrity (Burns & Grove, 2005:176). Certain procedures have to be followed in order to protect study participants; these include informed consent and participant authorisation, risk and benefit assessments, confidentiality procedures, and building ethics into the design of the study (Polit & Beck, 2008:184).

1.11.1 Informed consent and participant authorisation

Polit and Beck (2008:176) ascertain that "safeguarding participants and protecting their right to self-determination involves obtaining their informed consent". Informed consent also means that study participants receive adequate information pertaining to the purpose, method and reason for the research. The participants are advised that they have the freedom to choose to participate or decline participation without prejudice (Polit & Beck, 2008:176-177). For the purpose of the current study written informed consent was obtained from all the study participants who voluntarily agreed to participate (refer to Annexure B1).

1.11.2 Risk and benefit assessments

Risk and benefit assessment is designed to determine whether the benefits such as financial, physical, emotional or social are in line with the costs (Polit & Beck, 2008:174). The following was perceived as possible benefits and risks of this study:

1.11.2.1 Benefits: A potential benefit to the study's participants was that the knowledge derived from the inputs they gave might assist to improve nursing and medical care to the mechanically ventilated paediatric patient following cardiothoracic surgery in the PCCU.

1.11.2.2 Risks: No potential risk as study participants. The study participants attended the workshop in their off duty time, therefore patient care was not disrupted.

1.11.3 Confidentiality procedures

As stated by Polit and Beck (2008:180), the study participants have the right to expect that any data they provide will be kept in the strictest confidence. One example is maintaining anonymity where the researcher is unable to link the participants to their data (Polit & Beck, 2008:180). Anonymity implies that the study participants' identities are hidden in the research report (Oliver, 2010:77). It is also

Oliver's (2010:81) opinion that once the study participants are informed that their identities will be hidden, they may feel liberated and uninhibited and render truthful comments on the research issues. For the purpose of this study a workshop was conducted with eight critical care registered nurses and one physiotherapist. The names of these nine study participants on the consent documents could not be linked to any of the collected data. None of the study participants were required to write their names on the collected data. All the data were validated by experts and specialists and they could also not be linked to their inputs. These experts were required to sign consent forms, but not to include their names on the validated documents.

Confidentiality is another ethical procedure that was strictly adhered to in this study. Polit and Beck (2008:180) state confidentiality is a pledge that any information study participants provide, will not be publicly reported in a manner that may identify them and the information will not be made accessible to others. According to Oliver (2010:82), the discussion of confidentiality is part of the informed consent process. (Refer to Annexure B1).

1.11.4 External reviews and the protection of human rights

This study was approved by the University of Pretoria ethical committee which established that all ethical requirements were adhered to during the conduction of this study. This was done to ensure that the participants' human rights were protected throughout since, as noted by Polit and Beck (2008:184), researchers may not always be objective in assessing risk/benefit ratios or in the development of procedures to protect study participants' rights.

1.11.5 Building ethics into the design of the study

Researchers must persist in being attentive throughout the implementation of the research plans for any unforeseen ethical dilemmas that may arise during the study

(Polit & Beck, 2008:185). This study was conducted in an ethical and scientific manner.

1.12 LAYOUT OF THE CHAPTERS

The layout of the chapters is as follows:

- Chapter 1: Orientation to the study
- Chapter 2: Literature review
- Chapter 3: Research design and methods
- Chapter 4: Research findings and literature control
- Chapter 5: Conclusions and recommendations

1.13 CONCLUSION

In the background to the study in this chapter the issue raised was that up-to-date there had still been daily debates in the PCCU on when to extubate the mechanically ventilated paediatric patient following cardiothoracic surgery and what the sequence of events should be. It was furthered explained in the problem statement that prolonged mechanical ventilation might lead to several complications such as barotrauma, ventilator associated pneumonia and also to increased hospital costs.

The aim and objectives related to the development of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery which might bring an end to this debate and improve paediatric nursing care were presented. Chapter 1 included the definitions, the research method to be followed and noted the limitations of the study. Ethical considerations were presented and discussed. In Chapter 2 the researcher discusses the literature review of this study.

2 LITERATURE REVIEW

"The difficulty of literature is not to write, but to write what you mean"

-Stevenson 1850-1894-

2.1 INTRODUCTION

In Chapter 1 an overview and orientation to this study were provided. In this chapter the literature review is presented. Chapter 2 focuses on the exploration of literature related to the paediatric patient presenting with congenital heart disease, the mechanical ventilation of these patients, complications that may arise, and the extubation criteria of the mechanically ventilated paediatric patient.

2.2 PREVALENCE OF CONGENITAL HEART DISEASE

Congenital heart disease is defined as gross structural abnormalities of the heart or intrathoracic great vessels (Moons, Sluysmans, de Wolf, Massin, Suys, Benatar & Gewillig, 2009:1; Masood, Sahrif, Asghar, Qamar & Hussain, 2010:120). According to Sayasathid, Tantiwongkosri and Somboonna (2009:356), in many countries congenital heart disease is one of the most frequently reported diseases among newborns. Caneo, Jatene, Riso, Tanamati, Penha, Moreira, Atik, Trindade and Stolf, (2012:3) agree, stating that congenital heart disease is considered to be the first non-infectious cause of death in newborns. The term *congenital* is defined by Martin (2010:163) as a condition that is recognised at birth or which is believed to have been present since birth.

Potts and Mandleco (2007:771) point out that there is a minimum of 35 types of recognised congenital heart defects ranging from mild to complex. Ventricular septal defects (VSD) constitute 30-35% of all congenital heart diseases while tetralogy of Fallot makes up approximately 17% and atrial septal defects (ASD) about 15% of all congenital heart diseases (Masood, et al., 2010:120-121).

As reported by Healy et al. (2011:1), congenital defects in children are very common. Statistics on the prevalence of congenital heart diseases in infants and children around the world are provided in Table 2.1.

Table 2.1: Prevalence of congenital heart diseases in children worldwide

Country/area	Prevalence	Supportive authors
United States of America (USA)	8 infants per 1 000 live births	Potts and Mandleco (2007:771); Sayasathid et al. (2009:356)
Nigeria	1-3.5 infants per 1 000 live births	Olowu (2008:8)
South Africa	4-6 infants per 1 000 live births	Hewitson and Zilla (2010:20); Hoosen, Cilliers, Hugo-Hamman, Brown, Harrisberg, Takawira, Govendrageloo, Lawrenson and Hewitson (2010:5)
Thailand	8 infants per 1 000 live births	Sayasathid et al. (2009:356)
Asia	8 infants per 1 000 live births	Masood et al. (2010:120)
Belgium	8.3 infants per 1 000 live births	Moons et al. (2008:2)
United Kingdom (UK)	5-8 infants per 1 000 live births	Storey (2008:2)
India	4 infants per 1 000 live births	Masood et al. (2010:120)

Referring to Table 2.1, it is evident that approximately 8 out of 1 000 live born babies are born with congenital heart disease, this statement is supported by Zühlke, Mirabel and Marijon (2013:1). Caneo et al. (2012:3) state 30% of these patients require surgical treatment. In the opinion of Masood et al. (2010:120) the incidence of congenital heart disease is underestimated due to home deliveries and the early discharge of mothers and their neonates from hospitals without proper neonatal examination pertinent to the cardiovascular system.

Karthekeyan et al. (2010:1) and Shi et al. (2008:768) concur that an escalating number of paediatric patients around the world are requiring cardiothoracic surgery. Rashid, Satar, Kiran, Dar, Mudassir and Khan (2008:218) hold that the current procedure to mechanically ventilate paediatric patients following cardiothoracic surgery was already adopted in the 1960s. Moons et al. (2008:1) add that due to improved surgical, interventional and medical technologies, the life expectancy of the paediatric patient with congenital heart disease has increased significantly over the past five decades.

2.2.1 Indications for mechanical ventilation

The researcher discovered during the literature review that various authors concur that cardiopulmonary bypass is one of the most described indications for mechanically ventilating the paediatric patient following cardiothoracic surgery (Kanchi, 2005:33; Mittnacht, Thanjan, Srivastava, Shubhika, Joashi, Umesh, Bodian, Hossain, Sabera, Kin, Nobuhide, Hollinger & Nguyen, 2008:88; Apostolakis, Koletsis, Balkoussis, Siminelakis & Papadopoulos, 2010:1; Karthekeyan, Sundar, Sulaiman, Sajith, Ravulapalli, Harish, Vakamudi, Mahesh, Thangavelu & Priyasamy, 2010:3; Rodriques, de Oliveira, de Toledo Piza Soares, de Figueiredo, Araújo, Sebastiāo, Dragosavac & Desanka, 2010:375; Healy, Hanna & Zinman, 2011:3). Mittnacht et al. (2008:88) explain surgery for congenital heart disease using cardiopulmonary bypass requires mechanical ventilation that in many cases is continued post-operatively. These authors further warn that longer cardiopulmonary bypass time is associated with an increased risk of inflammatory response syndrome with generalised oedema, decreased respiratory compliance, acute lung injury and coagulopathy which all affect the ability to extubate the mechanically ventilated paediatric patient immediately after surgery (Mittnacht, et al., 2008:91). El-Kerdawy and Rasslan (2008:138) add that cardiac surgery induces the activation of the systemic inflammatory response, especially with cardiopulmonary bypass.

Karthekeyan et al. (2010:3) indicate that cardiopulmonary bypass has been associated with prolonged mechanical ventilation which may be due to the development of atelectasis and reduced lung compliance. Pulmonary function is affected by cardiopulmonary bypass-triggered inflammatory cascade effects (Rodrigues, et al., 2010:377; Roodpeyma, Hekmat, Dordkhar, Rafieyian & Hashemi, 2013:58). This inflammatory response is the result of the patient's blood contents getting into direct contact with the cardiopulmonary bypass circuit; the body releases inflammatory mediators which then causes systemic inflammatory response syndrome (Elzein, 2009:156; Rodrigues, et al., 2010:377; Healy, et al. 2011:3).

Since cardiac pathophysiology and pulmonary pathophysiology are interdependent, it makes the management of paediatric patients with congenital heart defects much more complex (Healy, et al., 2011:1); hence the next indication for mechanically ventilating the paediatric patient following cardiothoracic surgery, is limited cardiorespiratory reserve. According to Kanchi (2005:33), the paediatric patient with congenital heart disease has limited cardiorespiratory reserve. Healy et al. (2011:1) and Cooper et al. (2008:72) agree that in the healthy patient there is a close relationship between the anatomy and functions of the cardiovascular and respiratory systems. As mentioned in Section 1.2, Kanchi (2005:33) states that infants and children have important anatomical and physiological differences when compared to adults. For this reason, according to Kanchi (2005:33), children with congenital heart defects depend on a balance between the circulatory pathophysiology and compensatory mechanisms, thus presenting with diminished cardiopulmonary reserve and increased susceptibility to physiological insult.

Inotropic agent use is another indication to mechanically ventilate the paediatric patient following cardiothoracic surgery. Patients in the paediatric critical care unit (PCCU) frequently develop low cardiac output and hypotension due to cardiac dysfunction and the inflammatory cascade; however, inotropic agents can improve the haemodynamic parameters by increasing cardiac output (Parissis, Rafouli-Stergiou, Stasinos, Psarogiannakopoulos & Mebazaa, 2010:432). In fact, Kong, Chen, Hibben, Heer, Ahmadi and Lafzi (2008:1) and Parissis et al. (2010:433) confirm that all inotropic agents improve cardiac contractility through different pathways.

Another indication for mechanically ventilating the paediatric patient following cardiothoracic surgery is the administration of analgesia and sedation post-operatively (Kanchi, 2005:33). All thoracic surgery involves trauma near the diaphragm, causing pain which leads to limited respiratory motion (Canet & Mazo, 2010:139). These authors posit that, to reduce limited respiratory motion, the most important measure to implement post-operatively is the provision of adequate analgesia (Canet & Mazo, 2010:141); however, Newth et al. (2009:2) at the same time warn that over sedation may depress the central respiratory drive whereas under sedation can leave a child restless. Expounding on this view, Morandi, Brummel, and Wesley (2011:1070) and Shapiro, West, Nathens, Harbrecht, Moore, Bankey, Freeman, Johnson, McKinley, Minei, Moore, and Maier (2007:945) confirm that overuse of sedation and analgesia may have adverse effects such as haemodynamic instability and the prolonging of mechanical ventilation. (Refer to Section 2.3.5).

2.3 MECHANICAL VENTILATION

Mechanical ventilation is a rapidly advancing science (Nabi, 2005:31). Newth, Venkataraman, Shekhar, Willson, Meert, Harrison, Rick, Pollack, Murray, Zimmerman, Anand, Carcillo, and Nicholson (2009:1) believe the major intervention to prevent morbidity and death is mechanical ventilation. Mechanical ventilation is defined by Macintyre (2010:2084) as the "process of using devices to support the total or partial transport of oxygen (O_2) and carbon dioxide (CO_2) between the environment and the pulmonary capillary bed".

The objective of mechanical ventilation includes decreasing the oxygen cost of breathing by unloading the respiratory muscles and maintaining adequate gas exchange (McLellan & Walsh, 2004:2; Engelbrecht & Tintinger, 2007:2; Brander & Slutsky, 2008:231; Maung & Kaplan, 2012:3). Further goals of mechanical ventilation are described by Macintyre (2010:2084) as maintaining adequate levels of PO_2 and PCO_2 while unloading the respiratory muscles. Anderson and Younger (2010:23) maintain that once the need for mechanical ventilation has been established, three (3) questions should be answered to initiate support:

- What will constitute a breath?
- To what extent will the patient be allowed to participate in breathing?

- How will the support be delivered?

These three questions are referred to as the cycle, mode and method of mechanical ventilation (Anderson & Younger, 2010:23). As mentioned in Section 1.8.6.4, mechanical ventilation is a complex intervention in the PCCU with a wide variety of components (Maung & Kaplan, 2012:23). Mechanical ventilation can be life saving, but it also has its risks as stated by the American Thoracic Society (2005:1). There is a definite risk attached to prolonged mechanical ventilation which poses many potential complications such as increased hospital costs and nosocomial infection (Nabi, 2005:33; Venkataraman 2006:155; Newth, et al., 2009:1). To minimise the risk of the aforementioned complications the mechanically ventilated paediatric patient following cardiothoracic surgery should be weaned and extubated from mechanical ventilation as soon as possible.

2.3.1 Historical background

Kotur (2004:430, 2005:86) relates how theories of respiration can be traced back to ancient Egyptian, Chinese and Greek times. Kotur (2004:430) postulates that mechanical ventilation in medicine possibly originated as a final resort to assist or restore breathing to save a dying person's life. To assign truth value to this proposition, Kotur (2004:430, 2005:86) refers to the Bible (Kings 4 verses 34-35) which tells the story of how the prophet Elisha revived a dying child by inducing mouth-to-mouth breathing.

According to Kotur (2005:86), the first time endotracheal intubation was written about was in the book, *Treatise on Air*, by the Greek philosopher, poet and physician, Hippocrates, between 460-375 BC. Later, in 174 AD, the Roman physician Galen used fire bellows to inflate the lungs of a deceased animal; Paracelsus (1493-1541) used fire bellows connected to a tube into a patient's mouth as a device to assist with ventilation; Andrew Vesalius performed ventilation via a tracheostomy in a pig in 1543 and the first successful mouth-to-mouth resuscitation of a human being was reported by John Fathergill in 1744 (Kotur, 2005:86).

From the mid 1800-1900s an incredible number of devices were invented that applied negative pressure ventilation either around the body or the thoracic cavity (Kotur, 2004:430). The earliest breathing machine was the Drinker respirator. It was invented in 1929 by Drinker and McKhann; known as the *iron lung*, it introduced the first practical means of ventilation (Hamed, Ibrahim, Khater & Aziz, 2006:77). These machines were used between the 1930s and 1950s by patients whose breathing muscles had been paralysed by poliomyelitis. They used negative pressure to help patients breathe while lying inside the iron lung's airtight chamber. The negative pressure created a vacuum pump, enabling the expansion of the patient's chest (Hamed, et al., 2006:77).

In 1952 the Scandinavian polio epidemic resulted in the development of many principles of mechanical ventilation, such as the use of cuffed endotracheal tubes, periodic sigh breaths and weaning by reduction of assisted breaths (Kotur, 2004:430). In fact, the clustering of patients with respiratory failure supported on positive pressure ventilators in Copenhagen in the 1950s led the way to the development of the modern CCUs. Twenty years later the anaesthetist, Ibsen, recommended positive pressure ventilation via tracheostomies (Hamed, et al., 2006:78). The 1960s became an era of respiratory critical care (Kotur, 2005:86). According to Kotur (2004:430), a mechanical change of importance in the late 1960s and early 1970s was the introduction to positive end-expiratory pressure (PEEP).

2.3.2 Classification

Mechanical ventilators are classified according to the method of supporting ventilation (Smeltzer, Bare, Hinkle & Cheever, 2010:651; Geyer, et al., 2011:360). Smeltzer et al. (2010:651) explain that a mechanical ventilator is a positive pressure breathing device that can maintain ventilation and oxygen delivery for a prolonged period (refer to Section 1.8.6.4). There are two main classifications of mechanical ventilators: negative pressure ventilators and positive pressure ventilators (Morton, Fontaine, Hudak & Gallo, 2005:538). According to Macintyre (2010:2084) and Smeltzer et al. (2010:652), positive pressure mechanical ventilators are the most commonly used. Nabi (2005:31) states positive pressure ventilators are the mainstay of providing mechanical ventilation in PCCUs. Positive pressure ventilation generates airflow by increasing the proximal airway pressure above the alveolar pressure (Maung & Kaplan, 2012:1). By exerting positive pressure on the airway, air is pushed into the lungs and the alveoli are forced to expand during inspiration and expiration then occurs passively (Smeltzer, et al., 2010:652).

2.3.3 Modes

Singer and Corbridge (2009:1238) define the mode of ventilation as "determining how the mechanical ventilator initiates a breath, how the breath is delivered, and when the breath is terminated". Of the several ventilation modes that can be used, synchronized intermittent mandatory ventilation and pressure support ventilation are the modes most often used.

2.3.3.1 Synchronized intermittent mandatory ventilation

According to Carpenter, Dobyns, Grayck, Mourani, and Stenmark (2009:344) and Singer and Corbridge (2009:1240), synchronized intermittent mandatory ventilation (SIMV) is a commonly used mode of mechanical ventilation. SIMV is a complex mode of mechanical ventilation that has been developed to improve patient comfort by facilitating patient-device synchrony (Anderson & Younger, 2010:23).

SIMV mode can be a volume ventilation mode (Morton, et al., 2005:540) or a pressure targeted mode (Macintyre, 2010:2085). During SIMV the rate and tidal volume are pre-set (Morton, et al., 2005:540; Smeltzer, et al., 2010:655) and delivers a minimum number of fully assisted breaths per minute that are synchronized with the patient's respiratory effort (Hamed, et al., 2006:78; Singer & Corbridge, 2009:1240; Anderson & Younger, 2010:23; Macintyre, 2010:2086). This mode allows the paediatric patient to breathe spontaneously through the ventilatory circuit (Hamed, et al., 2006:78; Schilling McCann, 2006:259). The synchronization of the delivered breath to the inspiratory effort of the patient serves to avoid the potentially hazardous sequel of delivering a mechanical breath while the patient is in mid- or end-inspiration (Hamed, et al., 2006:78).

2.3.3.2 Pressure support ventilation

Pressure support ventilation mode is classified as a pressure mode of mechanical ventilation (Morton, et al., 2005:540). According to Hamed et al. (2006:79), pressure support ventilation is a popular mode of mechanical ventilation in spontaneously breathing patients since this mode of mechanical ventilation is patient triggered and allows the patient to actively control the start of each breath. The level of support pressure is set as opposed to tidal volume and background rate (Hamed, et al., 2006:79). A level of pressure is then delivered to the airways (Brander and Slutsky, 2008:235). The patient's breathing effort determines the rate and tidal volume during pressure support ventilation (Morton, et al., 2005:540). It is the opinion of Hamed et al. (2006:79) that pressure support ventilation has been used to limit barotraumas and to decrease the work of breathing. Anderson and Younger (2010:24) note the primary goal of pressure support ventilation is to support the patient's spontaneous breathing while providing satisfactory oxygenation.

2.3.3.3 Positive end-expiratory pressure

As defined by Brander and Slutsky (2008:243), PEEP refers to the airway pressure, relative to atmospheric pressure, at the end of a breath. Holleran et al. (2009:165) indicate that with PEEP resistance is applied to the expiratory phase of ventilation so that positive airway pressure is maintained throughout exhalation. According to Engelbrecht and Tintinger (2007:4), PEEP refers to a level of positive pressure maintained during the expiratory phase of ventilation which facilitates recruitment of the non-functioning regions of the lung. As stated by Singer and Corbridge (2009:1241), PEEP improves oxygenation by preventing alveolar collapse and decreasing intrapulmonary shunt.

Normal or physiological PEEP levels are 5cmH2O (Jauncey-cooke, Grad Cert, Bogossian & East, 2009:83; Singer & Corbridge, 2009:1241). According to Wittich (2008:155), optimal PEEP is the lowest level of PEEP needed to achieve sufficient oxygenation at a FiO_2 of less than 0,6. However, it was found in literature that there is controversy regarding the physiological PEEP levels. In Table 2.2 several physiological PEEP levels are listed.

Table 2.2: Physiological Positive end expiratory pressure levels

Physiological peep	Supportive authors
5cmH2O	Jauncey-Cooke et al. (2009:83); Singer et al. (2009:1241)
2-4cmH2O	Carpenter et al. (2009:344)
3-5cmH2O	Engelbrecht and Tintinger (2007:2)
3-8cmH2O	Hamed et al. (2006:79)

From Table 2.2 it is evident that many contradictions to physiological PEEP levels exist in the literature. (Refer to Section 4.4.3). The premature collapse of alveoli during expiration is prevented by PEEP (Roman & Brigham, 2007:254) and PEEP also aids in opening already collapsed alveoli to prevent atelectasis. PEEP also redistributes lung water from the alveoli into the interstitial space, thus reducing the shunt and increasing PaO2 (Heinds & Watson, 2005:984; Singer & Corbridge 2009:1241). According to Jauncey-Cooke et al., (2009:83), the goal of PEEP is to optimise alveolar ventilation. Another function of PEEP is to improve lung compliance and improve ventilation-perfusion matching (Wittich, 2008:155). Morton et al. (2005:488) hold that effective pulmonary gas exchange depends on a balance, or matching, of ventilation to perfusion. The ventilation-perfusion ratio is the ratio of pulmonary alveolar ventilation to pulmonary capillary perfusion (Potts & Mandleco, 2007:721). A ventilation-perfusion imbalance occurs when there is inadequate ventilation, inadequate perfusion, or both (Morton, et al., 2005:488).

Patients receiving PEEP should be closely monitored for barotraumas. A high PEEP may also decrease cardiac output by decreasing venous return to the heart (Anderson & Younger, 2010:24). Scohy (2012:84) indicates that in children who have had cardiothoracic surgery and who receive PEEP higher than 6cmH2O, a decrease in pulmonary blood flow and cardiac output occurs. High levels of PEEP are significant in hypovolaemic patients due to an already decreased venous return to the heart. This can be reversed by ensuring adequate intravascular fluid volumes

(Brander & Slutsky, 2008:243). According to Carpenter et al. (2009:344), high levels of PEEP may cause carbon dioxide retention, barotraumas, decreased central venous return, and an increase in intracranial pressure.

2.3.3.4 Continuous positive airway pressure

Continuous positive airway pressure (CPAP) provides for positive airway pressure during all parts of the respiratory cycle, but is applicable to spontaneous ventilation and not full mechanical ventilation such as PEEP (Morton, et al., 2005:542; Anderson & Younger, 2010:24). Hamed et al. (2006:79) state unlike PEEP, CPAP is an actual mode of ventilation. CPAP is indicated for paediatric patients who can spontaneously maintain optimal tidal volumes but who still needs the positive pressure and oxygen (Black & Hawks, 2005:1885; Schilling McCann, 2006:259). It is important though that the paediatric patient must have adequate respiratory drive and optimal respiratory function when CPAP is applied (Brander & Slutsky, 2008:243). The risks involved with CPAP are the same as with PEEP (refer to Section 2.3.3.3). According to Nabi (2005:32), prolonged endotracheal CPAP is not generally used because the high resistance of the endotracheal tube increases the effort of breathing.

2.3.4 Complications

Mechanical ventilation is a life saving therapy, but it is not without limitations (Jauncey-Cooke, et al., 2009:81). In fact, the researcher discovered discussions of several complications related to mechanical ventilation literature. Geyer et al. (2011:362) opine that complications of mechanical ventilation are mostly ascribed to the increase in intrathoracic pressure during positive pressure ventilation. The most prominent complications are related to the cardiovascular, respiratory and gastro-intestinal systems and are discussed in Sections 2.3.4.1 to 2.3.4.3.

2.3.4.1 Cardiovascular complications

Mechanical ventilation can decrease cardiac output because of the positive airway pressure applied to the lungs (Morton, et al., 2005:547; Anderson & Younger, 2010:26; Geyer, et al. 2011:362). The increase in positive airway pressure causes an increase in intrathoracic pressure which, in turn, diminishes blood flow towards the heart thus causing a decrease in cardiac output. A decrease in cardiac output may also cause hypotension as confirmed by Engelbrecht and Tintinger (2007:4) and Geyer et al. (2011:362). The increase in positive airway pressure causes the alveoli in the lungs to be distended thereby putting pressure on the pulmonary capillaries. The pulmonary capillaries are therefore being "stretched" which then causes an increase in pulmonary vascular resistance. This increase in resistance causes a decrease in oxygenation or gas exchange which may compromise the mechanically ventilated paediatric patient. Due to the decrease of oxygenation there is decreased perfusion of the body tissues (Heinds & Watson, 2005:984; Holleran, et al., 2009:167). It is evident that the mechanically ventilated paediatric patient following cardiothoracic surgery may become haemodynamically unstable, thus requiring constant monitoring in the PCCU.

2.3.4.2 Respiratory complications

Several respiratory complications of mechanical ventilation are mentioned by Hendrix and Russell (2012:2) and Moniz et al. (2013:49) and include barotraumas, oxygen toxicity, and ventilator associated pneumonia. Anderson and Younger (2010:26) are of the same opinion as Macintyre (2010:2094) that nosocomial pneumonia occurs in many mechanically ventilated paediatric patients and that the cause is largely due to oropharyngeal secretions leaking past the endotracheal tube to the lungs.

Morton et al. (2005:567), Potts and Mandleco (2007:721) and Martin (2010:577) all describe pneumonia as an inflammatory response to inhaled or aspirated foreign material or the uncontrolled multiplication of microorganisms invading the lower respiratory tract. Furthermore, the view of Morton et al. (2005:546) that aspiration is another complication of mechanical ventilation and can increase the risk of nosocomial pneumonia is supported by King (2010:2) and Burns (2007:63). According to Burns (2007:63), within "24-48 hours of exposure to a healthcare environment, organisms ubiquitous to the environment colonise the patient's artificial airway and, with aspiration, it may result in pneumonia". Although Burns (2007:64) observes that not all aspirations result in pneumonia, the author reasons that those that do so negatively affect morbidity, mortality, a patient's length of stay in hospital and hospital costs. Ventilator associated pneumonia is defined as "nosocomial pneumonia in a patient who has been mechanically ventilated for at least 48 hours at the time of diagnosis" (Morton, et al., 2005:547).

According to Loring and Malhotra (2007:646), more and more literature suggests that mechanical ventilation can promote lung damage when excessive pulmonary pressures are applied. Extreme hyperinflation of the lungs can occur and the alveoli can rupture (Singer & Corbridge, 2009:1243). Barotrauma is explained by Jauncey-Cooke et al. (2009:82) "as the impact of pressure related dysfunction". These authors indicate that positive pressure ventilation causes alveolar hyperinflation which subsequently causes damage to the pulmonary epithelial-endothelial barrier which allows air to shift into the pulmonary interstices.

Oxygen concentrations approaching 1,0 are known to cause oxidant injuries in the airways and lung parenchyma (Macintyre, 2010:2093). Even though toxic effects of oxygen are not well established in humans, when oxygen is administered in high doses or for a prolonged period it can cause pulmonary and systemic injury (Do Carmo Leite Machado Diniz, Gisele, Zin, Botoni, de Castro & da Glória Rodrigues-Machado, 2009:293; Jauncey-Cooke, et al., 2009:82). In fact, high oxygen concentration has been associated with atelectasis formation (Duggan & Kavanagh, 2005:842). Also, according to Macintyre (2010:2093), it is not clear what the safe oxygen concentration is or what the safe duration of exposure to oxygen should be while Singer and Corbridge (2009:1243) propose that oxygen toxicity is proportional to the duration of time that the patient is exposed to the fraction of inspired oxygen FiO_2 greater than 0,6.

2.3.4.3 Gastrointestinal complications

Gastrointestinal disturbances are mentioned by Hendrix and Russell (2012:2) as one of the several complications of mechanical ventilation. Gastrointestinal complications associated with mechanical ventilation include abdominal distension (due to air swallowed), intestinal hypomotility, and ileus development (Morton, et al., 2005:547). As stated by Pelosi, Quintel, and Malbrain (2007:78), intra-abdominal pressure markedly affects the function of the respiratory system. Abdominal distension can further apply pressure on the diaphragm, limiting lung expansion and decreasing tidal volume. Pelosi et al. (2007:78) add that increased intra-abdominal pressure decreases chest wall compliance and promotes excursion of the diaphragm, with consequent reduction in lung volume and atelectasis formation (refer to Section 4.3.5.1).

Hypomotility or delay in transit time from the stomach to the small intestine may be caused by the use of opioids, such as morphine, during mechanical ventilation (Chan, 2008:38). In Section 2.3.5 the side-effects of opioids are discussed. An ileus is defined by Morton et al. (2005:967) "as the failure of the intestinal contents to pass in the absence of mechanical obstruction". Martin (2010:367) defines an ileus as an obstruction of the intestines, which may be caused by hypomotility of the bowel. According to Morton et al. (2005:968), an ileus can cause pain, nausea and vomiting and abdominal distension. Geyer et al. (2011:362) state mechanically ventilated patients are prone to stress-induced gastric erosion and gastric ulcers.

2.3.5 Pain and sedation

Pain can be defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage" (Weisman & Rusy, 2006:436). As stated by Shapiro et al. (2007:945), sedation and analgesia are important components of the management of mechanically ventilated patients. In support, Maung and Kaplan (2012:13) add that patients requiring mechanical ventilation benefit from sedation and analgesia. Newth et al. (2009:1) claim that, because endotracheal tubes are uncomfortable to the intubated patient, the need for sedatives is increased. Marcdante, Kliegman, Jenson, and Behrman (2011:164) and Nair and Neil (2013:2) note that an acutely ill paediatric patient may have pain, discomfort and anxiety resulting from surgery and invasive procedures; therefore, as Shapiro et al. (2007:945) and Morandi (2011:43) believe, the central goal of using sedation and analgesia is patient comfort.

It is the opinion of Marcdante et al. (2011:164) goals of analgesia and sedation are to prevent anxiety and getting cooperation from the paediatric patient. Sedation is described by Martin (2010:662) as the production of a restful state of mind – particularly by the use of drugs. Morton et al. (2005:620) state the effective use of sedation will promote paediatric patient comfort and reduce respiratory effort, thus decreasing oxygen demand. Sedatives are mainly given in the PCCU to calm the paediatric patient and induce sleep; it ensures that the paediatric patient is more comfortable and peaceful and can tolerate the mechanical ventilator better. Since pain and anxiety are associated with intubation it is essential to recognise that sedation and analgesia are closely related – anxiety reduces the pain threshold but pain control reduces anxiety (Shapiro, et al., 2007:945).

Narcotic analgesics (opioids) such as morphine and benzodiazepines such as midazolam are the most traditionally used sedation during mechanical ventilation (Morandi, et al., 2011:43; Maung & Kaplan, 2012:13). Opioids, a term that refers to a large group of compounds and chemicals that share the characteristics of opium, have been used to manage pain for centuries (Chan, 2008:37). According to Nair and Neil (2013:6) morphine is the most valuable opioid for the treatment of severe pain. Some of the clinical effects that the opioid morphine has on the body are analgesic, sedative, and a delay in gastrointestinal transit time (Chan, 2008:38). Marcdante et al. (2011:165) add that morphine is the most frequent opioid used for patient-controlled analgesia.

According to Schellack (2004:81) and Marcdante et al. (2011:164), benzodiazepines have a variety of uses, including anxiolytic, sedative, hypnotic and muscle relaxant actions. Schellack (2004:82) states that midazolam works particularly well as a continuous intravenous agent. Adequate sedation is often equated with unresponsiveness; therefore the possibility that sedation itself contributes to prolonged mechanical ventilation must be seriously considered (Shapiro, et al., 2007:947). Before the paediatric patient can be weaned from the mechanical ventilator, he or she should be tapered off sedatives in order for him or her to breathe spontaneously (Black & Hawks, 2005:1893). (Refer to Section 4.3.1.1).

2.3.6 Weaning from mechanical ventilation and extubation

Newth et al. (2009:1) claim the initiation of weaning from mechanical ventilation and the timing of extubation has been largely neglected in the paediatric literature. Additionally, Stawicki (2007:13) opines that the science of determining if the patient is ready for extubation is still very imprecise despite advances in mechanical ventilation and respiratory support. Newth et al. (2009:1,9), Singer and Corbridge (2009:1243) and Farias and Monteverde (2006:322) concur that the critical care team must constantly search for new ways to better understand and develop parameters that can support the decision to interrupt mechanical ventilation as early as possible. Priebe (2011:1) argues that tracheal extubation is the logical consequence of tracheal intubation, and continued control of the airway after extubation constitutes part of the overall airway management; thus it appears logical that there would be an extubation algorithm which is pre-formulated. The author further states that no such guideline is available for the period during and immediately after extubation.

Weaning the paediatric patient from mechanical ventilation covers the entire process of removing the paediatric patient from mechanical support and from the endotracheal tube (Boles, Bion, Conners, Herridge, Marsh, Melot, Pearl, Silverman, Stanchina, Vieillard-Baron & Welte, 2007:1033; Wati, Dyah, Kanya, Pudjiadi, Antonius & Latief, Abdul, 2013:59). Casaseca-de-la-Higuera, de-Luis-García, Simmross-Wattenberg and Alberola-López (2005:1) explain that the process of weaning is the gradual removal of the mechanical support as spontaneous breathing is resumed.

For the purpose of this study, weaning from mechanical ventilation and extubation of the mechanically ventilated paediatric patient can be utilised interchangeably. According to Burns (2011:294), weaning is a process of the gradual reduction of ventilatory support; thus it is a plan for weaning which is determined by the multidisciplinary team members and that should be applied and monitored carefully.

Weaning from mechanical ventilation is explained by Brander and Slutsky (2008:250) as the transition from full ventilatory support to the resumption of unassisted spontaneous breathing by the paediatric patient. As stated by Smeltzer et al. (2010:661), weaning the paediatric patient from mechanical ventilation has to occur as soon as it is safe for the mechanically ventilated paediatric patient. The stance of Newth et al. (2009:2) is that there is no standard method of weaning. The process to achieve the goal of weaning the mechanically ventilated paediatric patient following cardiothoracic surgery includes preventing complications and restoring or maintaining physiological and psychological functional status (Morton, et al., 2005:557).

Once spontaneous breathing has been established, mechanical ventilator support should be slowly reduced. This process must be continued at a slow rate till the mechanically ventilated paediatric patient can manage full responsibility for his or her own ventilatory requirements (Black & Hawks, 2005:1894; Newth, et al., 2009:3).

As explained in Section 1.8.6.3, extubation is the act of the removal of the endotracheal tube. Readiness for extubation implies that weaning has been completed (Newth, et al., 2009:6). It is extremely important though that extubation should not be considered until the mechanically ventilated paediatric patient can cough, swallow, protect his or her own airway and is sufficiently alert (Heinds & Watson, 2005:986). Once the paediatric patient is weaned successfully from the mechanical ventilator, he or she may be extubated (Black & Hawks, 2005:1894).

Ingenito (2008:1688) notes that the removal of the mechanical ventilator requires that a number of criteria be met. These criteria are summarised in Table 2.3. The most general criteria to be met in order to wean the adult patient from mechanical ventilation as well as the inconsistencies described in literature are indicated in Table 2.3. Only the adult patient criteria are described as scant literature regarding criteria for the removal of mechanical ventilation in paediatric patients exists. It is the opinion of Newth et al. (2009:4) that although protocol-based weaning results in faster, earlier weaning with better outcomes in adults, the data are less solid for children.

Table 2.3: Summary of weaning and extubation criteria for the adult patient

Criteria	Value	Supportive authors
Haemodynamic status	Stable	Boles et al. (2007:1040) Engelbrecht and Tintinger (2007:4) Newth et al. (2009:6) Singer and Corbridge (2009:1244) Macintyre (2010:2097) Burns (2011:292)
Breathing	Spontaneous	Singer and Corbridge (2009:1244) Abdel-Aal (2010:25) Macintyre (2010:2097)
Airway reflexes such as coughing and swallowing	Present	Boles et al. (2007:1040) Engelbrecht and Tintinger (2007:4) Newth et al. (2009:6) Burns (2011:292)
PEEP	5-8cmH2O	Boles et al. (2007:1040) Engelbrecht and Tintinger (2007:4) Eskander and Apostolakos (2007:271) Brander and Slutsky (2008:255) Do Carmo Leite Machado Diniz et al. (2009:293)
	2-4cmH2O	Jones (2010:10)
FiO_2	Less than 0,4	Boles et al. (2007:1040) Engelbrecht and Tintinger (2007:4) Wittich et al. (2008:157) Do Carmo Leite Machado Diniz et al. (2009:293) Nemer, Barbas, Caldeira, Cárias, Santos, Almeida, Azeredo, Noé, Guimarães, and Suza (2009:2) Jones (2010:10) Burns (2011:292)
	Less than 0,5	Eskander and Apostolakos (2007:271) Brander and Slutsky (2008:255) Abdel-Aal et al. (2010:25) Burns (2011:292)

Criteria	Value	Supportive authors
PaO_2	More than 70mmHg	Engelbrecht and Tintinger (2007:4)
	More than 60mmHg	Eskander and Apostolakos (2007:271) Wittich (2008:157) Burns (2011:292)
$PaCO_2$	40mmHg	Burns (2011:292).
	Less than 50mmHg	Abdel-Aal et al. (2010:25)
Saturation	More than 92%	Engelbrecht and Tintinger (2007:4)
	More than 90%	Boles et al. (2007:1040) Nemer et al. (2009:2)
Tidal volume	More than 5ml/kg	Boles et al. (2007:1040) Eskander and Apostolakos (2007:267) Wittich (2008:157) Nemer et al. (2009:2) Burns (2011:292)
Pain	Controlled	Burns (2011:292)
pH	7.30-7.45	Boles et al. (2007:1040) Abdel-Aal, Attia, Youssef, Mohareb, Abdel Azeem, and Abdel Rahman (2010:25) Burns (2011:292)
	More than 7.25	Brander and Slutsky (2008:255)
Abdomen	Absence of distension	Burns (2011:292)

Table 2.3 summarises the weaning and extubation criteria for the adult patient, as no extubation criteria exists for the paediatric patient. At the end of weaning from mechanical ventilation is extubation, or the act of removal of the endotracheal tube (Newth, et al., 2009:2).

Extubation from mechanical ventilation is a process that should not be delayed unnecessarily or undertaken too early (Casaseca-de-la-Higiuera, et al. 2005:1; Mhanna et al. 2013:np) while Newth et al. (2009:1) and Wratney and Cheifetz

(2007:82) caution that premature as well as delayed extubation increases morbidity and mortality as well as hospital costs. It is stated by Karthekeyan et al. (2010:1) and Zureikat, Al-Madani and Makahleh (2005:40) that the potential benefits of early extubation from mechanical ventilation are lower nursing dependency, reduced airway and lung trauma, and reduced stress. This statement is in line with the view of Paarmann, Hanke, Heringlake, Heinze, Brandt, Brauer, Karsten and Schön (2012:1) that early tracheal extubation is linked to a decrease in CCU and hospital stay, morbidity and mortality, and a decrease in medical costs.

Extubation of the mechanically ventilated paediatric patient comprises of pre- and post-extubation care of the patient. Before extubating the mechanically ventilated patient, the airway should be suctioned, feeds should be stopped, re-intubation equipment should be ready and the patient should be monitored continuously (Hendrix & Russell, 2012:5). These authors stress that post-extubation care includes the monitoring of breath sounds and respiratory status, monitoring of the vital signs, and obtaining a chest X-ray. (Refer to Section 4.7).

Traditionally, children having cardiothoracic surgery requiring cardiopulmonary bypass have remained mechanically ventilated for prolonged periods post-operatively; however, the appropriate rapidity of extubation following cardiothoracic surgery remains controversial (Cooper, et al., 2008:81). According to Kanchi (2005:34), early extubation refers to tracheal extubation within a few hours (4-8 hours) following cardiothoracic surgery. Karthekeyan et al. (2010:3) perceives that although early extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery has been suggested as a safe alternative to prolonged post-operative intubation, it is still not common practice. Moreover, these authors state early extubation of the mechanically ventilated paediatric patient requires continuous evaluation and this can only be achieved if a multidisciplinary team approach is cultivated.

According to Smeltzer et al. (2010:662) and Wati et al. (2013:63) a multidisciplinary approach is needed during the weaning process in order to address patient problems. The paediatric patient is a candidate for weaning from the mechanical ventilator as soon as she or he is haemodynamic stable (Carpenter, et al., 2007:254; Wittich, 2008:157; Karthekeyan, et al., 2010:2). Haemodynamic stability is defined by Brander and Slutsky (2008:255) as “the absence of active myocardial ischaemia and the absence of clinically significant hypotension” (refer to Section 4.3.2).

One of the expected patient outcomes during weaning of the paediatric patient from mechanical ventilation is the absence of cardiac compromise which is evidenced by stable vital signs (Smeltzer, Bare, Hinkle & Cheever, 2008:751). The word *vital* is significant as it pertains to life forces such as blood pressure. Optimal cardiac performance is one of the most important criteria for weaning the paediatric patient from mechanical ventilation following cardiothoracic surgery (Heinds & Watson, 2005:986; Carpenter, et al., 2007:254; Brander & Slutsky, 2008:250). Haemodynamic instability can be defined as hypertension, hypotension and bradycardia (Pappada, Marina, Cesana, Parolin & Sganzerla, 2006:1). In accordance with the indicators of normal vital signs as outlined by Potts and Mandleco (2007:392-393) and Morton et al. (2005:128) Table 2.4 highlights the normal vital signs of the paediatric patient.

Table 2.4: Normal vital signs of the paediatric patient

Age	Resting pulse rate per minute	Average pulse rate per minute	Blood pressure systolic	Blood pressure diastolic
Newborn	100-170	140	46-92mmHg	38-71mmHg
3 years	80-130	110	72-110mmHg	40-73mmHg
10 years	70-110	90	83-121mmHg	45-79mmHg

(Adopted from Morton et al., 2005:128; Potts & Mandleco, 2007:392)

The normal vital signs of the paediatric patient are indicated in Table 2.4. In Table 2.5 the normal respiratory rate of the paediatric patient, as it differs in each age group, is indicated.

Table 2.5: Normal respiratory rate of the paediatric patient

Age	Resting respiratory rate	Average
Newborn	30-50	40
1 year	20-40	30
3 years	20-30	25
6 years	16-22	19
10 years	16-20	18

(Adopted from Potts & Mandleco, 2007:391)

Table 2.5 gives the resting respiratory rates for the paediatric patient in each age group.

Wittich (2008:157) proposes the most effective way of weaning the paediatric patient from mechanical ventilation is to use a nursing protocol. Morton et al. (2005:559) concur, adding that certain strategies can be used to influence weaning the mechanically ventilated paediatric patient following cardiothoracic surgery positively, namely, the use of multidisciplinary teams, standardised weaning protocols, and clinical pathways. Also, Brander and Slutsky (2008:250) advocate that weaning protocols designed for non-physician healthcare professionals should be developed and implemented in CCUs. Clinical pathways will be discussed in-depth in Section 2.4.

2.4 CLINICAL PATHWAYS

Morton et al. (2005:127) suggest facilitating optimal care of the critically ill paediatric patient, a framework for the adult critical care practice can be adopted and modified to include the paediatric patient. Such a framework can present as a clinical pathway as the latter is a powerful tool in maintaining clinical excellence and controlling hospital costs (Lombardo, et al., 2008:46). It is widely recognised that in the medical profession positive steps are constantly taken to improve and elevate quality and safety in healthcare (Demeulemeester, Sermeus, Beliën & Cardoen, 2007:452); therefore, the effectiveness of clinical pathways in providing positive, standardised, equal and quality care to all patients that is both timely and cost-effective should not be disputed (Curran, 2005:4; Muscholl, 2005:1). Rose et al.

(2007:435) further advocate that protocols such as clinical pathways are effectual methods of standardising clinical practice and providing nurses with increased autonomy and accountability.

According to Vanhaecht, Panella, van Zelm and Sermeus (2010:3), the rule when implementing a clinical pathway is to remember that although every patient is unique, they have enough in common to ensure that clinical pathways are a useful norm. Healthcare continues to change towards more patient-focused care; in fact, the organisation of the care process related to quality, efficiency and accessibility is one of the main areas of interest for clinicians, healthcare managers and policy makers (Vanhaecht, et al., 2010:1). According to these authors, the main method to organise a care process is to develop and implement a clinical pathway.

2.4.1 History of clinical pathways

Clinical pathways originated from industrial processes and were introduced in healthcare in the early 1980s in the USA (Vanhaecht, et al., 2010:2). In 1985 the first clinical pathway was used in the New England Medical Centre in Boston in the USA (Demeulemeester, et al., 2007:454; Vanhaecht, et al., 2010:2). According to Vanhaecht et al. (2010:2), in the early 1990s clinical pathways were introduced to the UK while in the late 1990s more that 80% of the hospitals in the USA used clinical pathways. Subsequently, as stated by Vanhaecht et al. (2010:2), clinical pathways were disseminated all over the world by the beginning of the 21st century.

2.4.2. Definition

The European Pathway Association defines clinical pathways as “a methodology for the decision making and organisation of care for a well-defined group of patients over a well-defined period of time”. Lombardo et al. (2008:46) and Arora (2013:np.) note that a clinical pathway is a strategy of managing care that emphasises early assessment of a patient’s condition and comprehensive care planning. Vanhaecht et al. (2010:2) define clinical pathways as “tools for designing care processes, implementing clinical governance, streamlining delivered care, improving the quality of clinical care, and ensuring that clinical care is based on the latest research".

In Muscholl's (2005:1) view, clinical pathways are "multidisciplinary plans of best clinical practice" which also refers to as evidence-based practice. Evidence-based practice is "the process of integrating individual clinical expertise with the best available external clinical evidence from systematic research" (Pai, et al., 2004:86; Morton, et al., 2005:4).

2.4.3 Characteristics and advantages

A clinical pathway gives a statement of the goals and objectives of the pathway based on evidence (Vanhaecht, et al., 2010:2). These authors add that clinical pathways facilitate communication, determine the different roles of the multidisciplinary team members and their activities. This is confirmed by Kelly-Heidenthal (2003:260) who notes that clinical pathways are very instructive for new staff members. Clinical pathways always deal directly with the implementation of the goals and objectives (Demeulemeester, et al., 2007:455).

Curran (2007:4) and Salter (2005:29) note several advantages of clinical pathways such as improving consistency, enhancing teamwork among the multidisciplinary team members, promoting patient-focused care, and ameliorating the use of several resources to their maximum. Renholm, Leino-Kilpi and Suominen (2002:196) state clinical pathways have a positive impact on outcomes such as quality of care and patient satisfaction; the use of a clinical pathway is effective in minimising the probability of medical errors (Vanhaecht, et al., 2010:1), and they always provide a guide to the care of the patient as well as a legal record for the care provided (Salter, 2005:29; Curran, 2007:4).

Conducting high quality studies creates strong evidence that allows for evidence-based decisions to be made. Experience-based pathways are being replaced by evidence-based pathways (Demeulemeester, et al., 2007:455). It is the opinion of Evans-Lacko, Jarrett, McCrone and Thornicroft (2010:182) that clinical pathways may serve as useful and evidence-based tools to reduce variations in clinical practice and improve quality and outcomes of healthcare interventions. Salter (2005:29) mentions that advocates of clinical pathways recognise that the use of a multidisciplinary team is essential to ensure that the best standard of care is developed for the patient. Similarly, Renholm et al. (2002:198) note that the continuity of care is improved with the use of clinical pathways since it assists the staff to think about patient care from a team perspective.

Kelly-Heidenthal (2003:261) observes that, despite the fact that some specialists have an issue with the development of a clinical pathway as they perceive it as “cookbook” medicine and are reluctant to participate in its development, specialist participation is nonetheless critical.

2.4.4 Development

The development of a clinical pathway involves a process of development from best evidence and implementation and, in the opinion of Vanhaecht et al. (2010:4), it is essential for the multidisciplinary team members to be involved. In other words, as put by Evans-Lacko et al. (2010:183), a sense of participation should be present during the pathway design.

Different models of clinical pathways exist, namely, chain models, hub models and web models (Vanhaecht, et al., 2010:4). As these authors explain, chain models are used for a high predictable care process with a high level of agreement between the team members with, for example, elective surgery. Hub models are used for less predictable processes like rehabilitation and psychiatry. Web models are used for unpredictable processes where it is necessary to have daily multidisciplinary team meetings to be able to structure the process. One of the goals of each of the models is to enhance multidisciplinary teamwork (Vanhaecht, et al., 2010:3). The development of a clinical pathway is discussed in more detail in Chapter 3 and illustrated in Chapter 4.

2.5 CONCLUSION

In Chapter 2 the literature pertaining to the mechanically ventilated paediatric patient was explored and discussed. In Chapter 3 the research methodology of this study is explained and discussed in detail.

3 RESEARCH DESIGN AND METHODS

"To design is to plan, to order, to relate and to control".

-Emil Ruder (1914-1970)-

3.1 INTRODUCTION

Chapter 2 was dedicated to the literature review of the study. Based on the literature the researcher defined and described the paediatric patient following cardiothoracic surgery, mechanical ventilation, the indications and contraindications of mechanical ventilation, weaning the paediatric patient from mechanical ventilation as well as the extubation of the paediatric patient following cardiothoracic surgery.

In Chapter 3 the researcher describes the research methodology in terms of the research design and methods, which was used to address the aim and objectives of this study.

3.2 RESEARCH DESIGN

Yin (2011:75) states every research study has a design and that the researcher should use a strong design to strengthen the validity of the study. According to Polit and Beck (2008:765) a research design entails the overall plan for addressing the research question. In this study a qualitative, contextual, explorative and descriptive design was utilised. Each of these aspects will be discussed in Sections 3.2.1-3.2.4.

3.2.1 Qualitative research

In the opinion of Struwig and Stead (2004:11) qualitative research is a difficult concept to define as qualitative research does not describe only a single research method. Cresswell (1984), cited in Klenke (2008:7) defines qualitative research as being interpretative and naturalistic in nature. Qualitative research can be viewed as multi-method, interdisciplinary and multi-paradigmatic (Struwig & Stead, 2004:11). In qualitative research the study design typically evolves over the course of the project (Polit & Beck, 2008:219). During the course of this study, the researcher developed a clinical pathway for the extubation of the mechanically ventilated paediatric patient, which evolved as the study progressed.

According to Struwig and Stead (2004:11) and Polit and Beck (2008:763), qualitative research is described as the investigation of a phenomenon, typically in an in-depth and holistic fashion. Merriam (2002:5) opines that a qualitative study is often undertaken due to a lack of theory to adequately explain a phenomenon. For the purpose of this study the phenomenon was the collaboratively determination of the components of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery in a private hospital in Gauteng.

One of the characteristics of qualitative research is mentioned by Yin (2011:8) whom states qualitative research has the ability to represent the views and perspectives of the participants. This statement is supported by Struwig and Stead (2004:12) which state that qualitative researchers are trying to "see through the eyes of the participants". The researcher utilising qualitative methods are interested in understanding the participant's views based on their experience at a particular point in time and in a particular context (Merriam, 2002:4). As mentioned, the participants in the current study were requested by the researcher to discuss the components of the clinical pathway for the extubation of the mechanically ventilated paediatric patient in their allocated groups and give feedback afterwards. Yin (2011:8) further states that qualitative research covers contextual conditions (refer to Section 1.9.2). A second characteristic of qualitative research entails contextualism (Struwig & Stead, 2004:12). Refer to Section 3.2.2 on a discussion of a contextual design.

According to Polit and Beck (2008:219), a qualitative design involves the combination of various data collection strategies. One of these strategies is triangulation, which is defined by Polit and Beck (2008:768) as "the use of multiple methods to collect and interpret data about a phenomenon so as to converge on an accurate representation of reality". Qualitative research strives to utilise multiple sources of evidence, instead of using one source alone (Yin, 2011:8). Struwig and Stead (2004:11) are of the opinion that qualitative research entails the usage of several research methods such as interviews, focus groups and content analysis. The researcher used a workshop, written feedback, photographs, field notes and literature as methods of data collection in this study. Merriam (2002:5) states that a qualitative study is "richly descriptive" using pictures and words to convey the research findings about a phenomenon. Triangulation entails collecting material in as many different ways and from as many diverse sources as possible (Kelly, 2009:287). For the purpose of this study the researcher made use of the multidisciplinary team as the population and sources. The purpose of a qualitative design, and specifically triangulation, is to be thorough and to be able to understand the whole. Triangulation is further defined by Fox and Bayat (2007:107) as a "process of finding convergence among sources of information, different researchers or different methods of data collection".

Merriam (2002:5) and Polit and Beck (2008:219) hold that during a qualitative study the researcher is required to become the research instrument. In this study the researcher facilitated a workshop in order to collect data for the development of a clinical pathway for the extubation of the mechanically ventilated paediatric patient (refer to Section 3.3.3). The concept of the researcher becoming the research instrument used for data collection is also a very distinctive characteristic of qualitative research (Driessnack, et al., 2007:685). While the researcher becomes the research instrument, she can expand her understanding through verbal and nonverbal communication (Merriam, 2002:5). In accordance with Graneheim and Lundman's (2004:106) view that qualitative research requires understanding and cooperation between the researcher and the participants, the researcher worked in the specific PCCU at the time the current study was conducted. Hence, in this study she did not only take on the role of the researcher, but also that of a colleague and member of the multidisciplinary team. To further ensure cooperation between the researcher and the participants, general ground rules were laid down and agreed upon by all at the beginning of the workshop (refer to Section 3.3.3).

According to Creswell (2003:179) qualitative research can be interpretative research with the inquirer (researcher) typically involved in an intensive and continuous experience with the participants. As a critical care registered nurse and a member of the multidisciplinary team at the PCCU where this study was conducted, the researcher facilitated a workshop (see Section 3.3.3) with multidisciplinary team members such as critical care registered nurses and physiotherapists as part of her ongoing experience with the participants.

Three advantages of qualitative research are described by Mack, Woodsong, MacQueen, Guest and Namey (2009:4). The first advantage described is the opportunity to have direct contact with the participants. During qualitative research the researcher is allowed to talk directly and face to face with the participants. The workshop which the researcher facilitated enabled her to have direct contact with every participant. The second advantage is that open-ended questions are asked which initiates responses that are meaningful, rich and explanatory. Open-ended questions are described by Polit and Beck (2008:414) as a type of question that allows the participants to respond in their own words in a narrative fashion. The researcher prepared several written open-ended questions in advance and gave a copy to each participant during the Workshop.

The third advantage, namely that the participants are given the opportunity to respond to questions in their own words, was also observed. The participants were requested to answer the open-ended questions in writing and every group (three groups, three participants in each group) had to reach consensus on the answers. Thus every participant was afforded the opportunity to respond in his or her own words and answer the questions as thoroughly as possible. The researcher has the flexibility to probe participant responses for further explanations and clarifications, as qualitative research is a process used to generate ideas. During the workshop the researcher requested each group leader to give verbal feedback to the rest of the group and consensus was then reached from all study participants. Each group leader was selected among the group members. The researcher had ample time to request explanations and clarifications on the collected data.

3.2.2 Contextual design

During qualitative research, it is essential to provide a comprehensive description of the environment in which the study occurs (Struwig & Stead, 2004:12). With a contextual design the aim is to describe and understand events within the natural setting in which they occur (Babbie & Mouton, 2001:272). The natural setting in this study was the PCCU in a specific private hospital in Gauteng. Strőmberg (n.d.:n.p.) states the setting includes the environment where the data were collected, a description of the sample, and whether there were non-participants present during the data collection. The context for the purpose of this study was an eight-bed PCCU in a private Level 3 hospital in Gauteng, South Africa. The PCCU admitted children from infancy (28 days) to 12 years of age; hence paediatric patients (refer to Section 1.8.6.7). Generally, cardiothoracic and medical paediatric patients make up the majority of patients in this PCCU. In Table 1.1 a summary of the number of general admissions and the total of cardiothoracic surgery paediatric patients admitted in the relevant PCCU are given. For the purpose of this study, the researcher focused on the paediatric patients following cardiothoracic surgery. The sample in this study was the members of the multidisciplinary team such as paediatricians, critical care registered nurses, and a physiotherapist (refer to Section 3.3.2). One non-study participant, namely the independent coder who documented the data, was present during the data collection process.

3.2.3 Explorative design

According to Struwig and Stead (2004:7), exploratory research is the investigation of an area or domain that has not been fully explored. It involves gathering a great deal of information from a small sample (Struwig & Stead, 2004:7). The sample involved in this study included eight critical care registered nurses, one physiotherapist and seven experts. An explorative design relates to an investigation of the full nature of the described phenomenon, the manner in which the phenomenon is manifested, and other factors to which it is related (Polit & Beck, 2008:20). The phenomenon investigated in this study was the components of the clinical pathway for the extubation of the mechanically ventilated paediatric patient (refer to Section 1.8.3). For the purpose of this study, the researcher developed a clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery in a private hospital in Gauteng.

Durrheim (2009:44) explains that exploratory studies are undertaken to make preliminary investigations into relatively unknown areas of research. As stated in Section 2.3.6, the literature review revealed that criteria relating to paediatric weaning and extubation were minimal. Moreover, in the relevant PCCU no criteria existed or were available as regards the weaning and extubation of paediatric patients (refer to Section 1.3). Section 1.3 gives an indication to the origination of this study.

The three methods used in exploratory research mentioned by Struwig and Stead (2004:7) comprise the facilitation of a workshop where participants can combine ideas and generate new information; the study of secondary sources which implies the use of literature; and the analysis of the selected information and ideas. In this study the researcher used all the three the aforementioned methods to obtain relevant data with regard to the development of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery. The researcher read multiple books and articles, facilitated a workshop and finally analysed the collected information.

3.2.4 Descriptive design

Polit and Beck (2008:19) defines a descriptive design as the description of the variations and significance of the phenomenon. The phenomenon entails the components of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery. The researcher found many variations and contradictions in literature pertaining to extubation criteria. These discrepancies are discussed in detail in Chapter 4. The researcher's endeavour with this study was to appropriate a new idea, namely the development of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery, to improve critical care practice and the overall care of paediatric patients in the PCCU (refer to Section 1.7) and, in the larger context, to ameliorate nursing practice in general.

As stated by Struwig and Stead (2004:8), descriptive research attempts to describe something, such as the components of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery and provide a complete and accurate description of a situation, such as the limited literature on the extubation of the paediatric patient following cardiothoracic surgery. In Chapter 4 the researcher describes the research findings and compiles a clinical pathway for the extubation of the mechanically ventilated paediatric patient. According to Tredoux and Mario (2009:167) the key aim in descriptive research is to describe aspects such as the distribution of attributes in a population (refer to Table 3.1). Fox and Bayat (2007:8) state a descriptive design is aimed at casting light on current issues or problems through a process of data collection that enables the researcher to describe the situation. Data collection methods used for the purpose of this study was a literature control and the conduction and facilitation of a workshop. Also stated by Fox and Bayat (2007:8), the descriptive design is suitable for situations where the researcher believes that the information which exists is not sufficient or detailed enough to solve the problem (refer to Sections 1.1 to 1.3 and Section 2.3.6).

3.3 METHODS

As stated by Polit and Beck (2008:15) a research method is the approach the researcher uses to structure the study, to collect data and to analyse the data. This study was conducted in two phases namely phase one, being the components of the clinical pathway and phase two, development of the clinical pathway. Refer to Table 1.4 for a summary of the research method. The methods in each phase will be discussed independently.

Phase 1: Components of the clinical pathway

Phase 1 consisted of four steps. Step (1) was the selection of a specific population relevant to this study; (2) entailed the sampling method; (3) involved the data collection strategy and (4) described the data analysis.

3.3.1 Population

According to Polit and Beck (2006:506), a *population* is the complete set of individuals sharing common characteristics. For the purpose of this study the population was the multidisciplinary team members working with the paediatric patients in the PCCU of a specific Level 3 private hospital in Gauteng. The common feature shared among the multidisciplinary team members was that they all had diverse knowledge and skills that complemented each other in practice. However, it has to be acknowledged that some limitations were encountered by choosing the population used for this study (refer to Section 1.6). In brief, the limitations included that purposive sampling was used which did not represent the entire population under study; the population under study was in one specific location, namely Gauteng and was therefore not generalisable; the inclusion criteria (also known as eligibility criteria) minimised the population size and was thus not applicable to the inclusion criteria for other populations.

The inclusion criteria for this study were that all the participants had to:

- be part of the multidisciplinary team working with the mechanically ventilated paediatric patient following cardiothoracic surgery in the PCCU of the specific private hospital in Gauteng
- be a critical care healthcare professional and either had to be registered at the South African Nursing Council as a registered nurse or at the Health Professions Council of South Africa as a physiotherapist.

3.3.2 Sampling

A *sample* is defined as a portion of the population that represents the entire population (Polit & Beck, 2008:765). *Sampling* on the other hand is described by Polit and Beck (2008:765) as the "process of selecting a portion of the population" in order to represent the total population. De Vos, Strydom, Fouche and Delport (2005:194) state the reason for sampling is feasibility. Purposive sampling was utilised in this study. According to Polit and Beck (2008:343), purposive sampling can be used when the researcher is knowledgeable enough about the population to select sample members, as the researcher is involved in the setting. In this study, the researcher's decision regarding the selection of the study sample was guided by the inclusion criteria and the number of years clinical experience each study participant had (refer to Table 3.1). Purposive sampling is based entirely on the judgement of the researcher (De Vos, et al., 2005:202).

There were a total of nine critical care registered nurses in the PCCU one of whom was the researcher. The number of physiotherapists accredited to work in PCCU was limited and only one was sampled. The term *accredited* is defined by Waite (2006:10) as "to be officially recognized". Eight critical care registered nurses (which excluded the ninth since it was the researcher) and one physiotherapist were selected to participate in this study. Table 3.1 provides a summary on the participants and their demographic data.

Table 3.1: Summary of study participants and demographic data

Demographic data of critical care registered nurses		Number of study participants
Qualifications	**RN (General)**	2
	Comprehensive four year programme	3
	BCur (Hon)	1
Qualifications	**BCur (I et A)**	1
	PhD	1
ICU	**Trained**	7
	Experienced	1
Years registered	**>5**	4
	>20	2
	>25	1
	>30	1
Years' experience in paediatrics	**>2**	2
	>10	5
	>20	1
Sector	**Private**	2
	Public	6

Demographic data physiotherapist		Number of study participants
Qualification	**B.PhysT**	1
Years registered	**>10**	1
Years' experience in paediatrics	**>10**	1
Sector	**Private**	1
	Public	0

Table 3.1 summarises the demographic data of all the participants but still protects their identity thereby and promoting anonymity (refer to Section 3.5.2). During Phase 1 paediatricians were not used as these specialists were used during Phase 3 (refer to Section 3.3.7) during the refinement of the clinical pathway.

3.3.3 Data collection

Collecting qualitative data involves various processes; in fact, it is seldom found that only one form of data collection is employed to collect qualitative data (Fox & Bayat, 2007:71). In the current study the data collection process involved a thorough literature review that was conducted by the researcher, and a workshop facilitated by the researcher during which verbal and written information was obtained from the participants. Fox and Bayat (2007:71-72) state interviews as a form of data collection can be conducted on a one-on-one basis or as a workshop. For the purpose of this study the researcher made use of a workshop.

3.3.3.1 Definition of a workshop

Workshops or focus groups are group interviews which, according to De Vos et al. (2005:299), is a method used by researchers to gain a better understanding how people feel or think about an issue. Strydom (2011:503) describe both a workshop and a focus group as part of data collection methods. The researcher will draw a comparison for the purpose of this study. Refer to Table 3.2.

Table 3.2 Comparison between a workshop and focus group

Characteristics	Workshop	Focus group
Method	Data collection	Data collection
Participants	Specifically targeted/selected	Specifically targeted/selected
Size	Larger group	Smaller group
Objective	Learning process between researcher and participants	Apply knowledge and experience of participants

(Strydom, 2011:503)

In this study, the term *workshop* was used instead of *focus group*. "Workshops can lead to significant advances in theoretical understanding of reality and is particularly good at enabling the researcher to learn first-hand about people's perspectives" (Davies, 2007:29). Workshops are advantageous in the sense that the participants get to hear each other's responses and can then make additional comments or give more detail on an issue (Merriam, 2009:98) thereby ensuring that, firstly, more in-depth data are collected and, secondly, it ensured that every participant could contribute towards the discussion.

A workshop is defined by Merriam (2009:93) as a method of qualitative research data collection involving an interview with a group of people who have knowledge of the topic under investigation. Polit and Beck (2008:754) define a focus group as an "interview with a group of individuals assembled to answer questions on a given topic" (Refer to Annexure B2). During a workshop one of the main activities is brainstorming. Brainstorming, the brainchild of an advertising executive in 1939, Alex Osborne, is a method of thinking up solutions, ideas or new concepts in a group (Thomson, 1996:95; Tidd, Bessant & Pavitt, 2005:1). Kreitner and Kinicki (2007:390) define brainstorming as a process to generate a quantity of ideas and also new ideas.

Workshops or focus groups may be used as a way to collect data for instrument development (De Vos, et al., 2005:300). For the purpose of this study a clinical pathway was developed as an instrument for the extubation of the mechanically ventilated paediatric patient. It is the opinion of De Vos et al. (2005:300) that workshops are useful when multiple viewpoints or responses are needed on a specific topic. Careful planning with respect to study participants, the environment and the questions to be asked was regarded as crucial to conducting an effective workshop (De Vos, et al., 2005:303). Davies (2007:30) states the ideal number of group members is between six and eight individuals. Nine members of the multidisciplinary team attended the workshop in this study. During a workshop there is continual communication between the researcher and the participants as well as among the participants themselves (De Vos, et al., 2005:300). This was evidenced by the researcher during the facilitation of the workshop, the group discussions and the feedback given by each group leader.

3.3.3.2 Process of a workshop

The suggestions by De Vos et al. (2005:303) were used to plan a workshop. The first decision is to define the purpose and outcomes of the study, secondly, to obtain all necessary permission from the selected participants (refer to Annexure B1) and thirdly, a timeline must be developed for the workshop. The workshop programme (see Annexure B3) was handed in writing to each study participant prior to the workshop in order to give direction and guidance to the planned activities.

The final decision is to write down the questions and set the location, date and time for the workshop. A formal invitation was sent to the participants to invite them to the workshop presented on the 18th September 2012 @ 09:00.

The environment should be appropriate for learning and participative discussions. The venue was a conference room on the eighth floor of the Department of Nursing Science at the University of Pretoria. There were tables and enough chairs around each table to facilitate group work. A name card for each of the nine group members was placed on the tables to confirm the seating. The seating arrangement was done so that each group was made up of three participants with various and different expertise and knowledge to represent diversity. Water, coffee, tea and snacks were provided by the researcher. The conference room had sufficient ventilation and an appropriate temperature. (Refer to Annexure B2 for photos of the workshop). The equipment needed and provided for the workshop was as follows:

- flip charts for writing notes
- enough markers and pens for each individual in order to give written feedback
- paper for individual work and charts for group work (each group had a different colour chart)
- handouts such as consent forms, programmes and evaluation forms
- a digital camera for data recording
- a notebook and pen for field notes for data recording
- Prestik to attach the charts to the wall during feedback
- name cards (for seating arrangements)
- peppermints on each table
- water, coffee, tea and snacks.

Kreitner and Kinicki (2007:353) explain that a workshop has several advantages as well as disadvantages which are discussed next in Section 3.3.3.3.

3.3.3.3 Advantages and disadvantages of a workshop

Advantages: A greater pool of knowledge is generated. The participants bring a lot of information and professional experience to the table. All participants' perspectives are different because they each have different professional experience. This allows the participants and the researcher to view aspects from different angles. There is increased acceptance of ideas as the participants view all decisions as "ours" and not "theirs".

Disadvantages: During the workshop the participants can experience social pressure from their peers which may suppress their creativity. One participant may dominate the group by talking louder and longer and this may be very intimidating to the rest of the participants. Goal displacement can occur where a participant loses focus of the goal and simply wants (or needs) to win an argument to make a point.

For this reason the researcher and the participants need to agree on general ground rules at the start of the workshop to avoid participant domination, goal displacement and any unacceptable behaviour.

The workshop for this study was facilitated by the researcher with eight critical care registered nurses and one physiotherapist. The participants were divided into three groups with three participants in each group in order to facilitate equality. Photograph 3.1 was taken by the researcher with a digital camera during the workshop. The participants were brainstorming and writing down information.

As visible in the photograph there were name cards on the table, water and glasses, written directions and questions compiled by the researcher, paper and markers that were provided to the study participants.

Photograph 3.1: Workshop in progress (with consent of participants)

In Photograph 3.1 participants are brainstorming and data were written down. Fox and Bayat (2007:74) state continuous recording of data is an essential part of the research process. According to Davies (2007:162), there are three ways to keep record during an interview or workshop, namely, written notes, audio-recording and video recording. For the purpose of this study, three strategies were used to record data during the workshop. In addition use of the participants' written notes and the field notes made by the independent coder during the workshop (refer to Annexure B2). Photos were taken with permission of the participants with a digital camera as proof of the recorded data and the workshop (refer to Annexure B2). Since the participants needed to feel comfortable with the mode of recording used, the researcher informed all participants verbally of the data recording methods that would be used and none objected to the photographic recording (Henning, et al., 2004:3).

3.3.4 Data analysis

Data analysis is employed to clarify and refine the terms, concepts and statements in the collected data (Fox & Bayat, 2007:106). This is the stage after the data have been collected and before beginning the report on what the research process has revealed (Lewis, 2012:1). Content analysis was used to analyse the data. Qualitative content analysis is defined by Polit and Beck (2008:517) as "the analysis of the content of narrative data to identify prominent themes and patterns among the themes".

Qualitative content analysis involves breaking down the gathered data into smaller units and grouping these units together. Polit and Beck (2006:498,507) state data analysis is the systematic organisation, interpretation and synthesis of research data for the purpose of discovering important dimensions, and the "testing of research hypotheses using that data" and also to classify the collected data and give structure to it. Fox and Bayat (2007:105) note that qualitative research has various data analysis procedures. In the current study the researcher made use of content analysis. This meant all the data were broken down into smaller units and similar concepts were grouped together. According to Creswell and Clark (2007:129), there are the following four procedures of data analysis in qualitative studies: preparing the data for analysis, exploring the data, analysing it and presenting the data analysis. Each of these aspects will be discussed in Sections 3.3.4.1-3.3.4.4.

3.3.4.1 Preparing the data for analysis

After having obtained all the data, the first step is to get it into the format for analysis (Lewis, 2012:2). Written documents and notes were the format used for the current study. The researcher started the data analysis process by converting the raw data into a useful form (refer to Table 4.1 for a summary of the research findings). For qualitative data, preparing means organising the data for transcription purposes; in the case of this study it referred to the data collected through the written notes and the photographs taken during the workshop. The participants were asked by the researcher to answer several questions in writing. An independent coder was used to write down all the information on a flipchart during the consensus reaching stage of the workshop. The researcher also took several photographs of the flipchart, on which consensus was reached about the components of a clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery. All of the information was taken by the researcher, explored, read through and grouped together.

3.3.4.2 Exploring the data

Exploring the data means to read through it, make notes and to develop a preliminary understanding of the database. According to Lewis (2012:6), all collected data should be collated in one place, worked through, and then formed into independent segments or codes. All forms of data were read through and reviewed by the researcher, including the individual page of participants field notes and photographs of flipcharts taken during the workshop. From the written data, the researcher grouped all similar information together into themes. These themes are derived from the nursing process which was used as the conceptual framework of this study. These themes were: assessment, planning, implementation, evaluation and documentation. Any contradictive information was kept and acknowledged. Yin (2011:183) asserts that the researcher should get to “know” the field notes by continually reviewing them. The researcher went through all the documented data numerous times to ensure no information was missed or misinterpreted. The researcher hence explored all the collected data and developed a general picture of it.

3.3.4.3 Analysing the data

Qualitative analysis begins with coding the data, dividing the text into small units such as phrases and sentences, and assigning a label to each unit. Further, the codes should be grouped and organised into categories or themes (Lewis, 2012:7). This was done by categorising the information according to the nursing process and further sub-dividing the information according to body systems. The body systems comprises of the central nervous, cardiovascular, respiratory, renal and gastro-intestinal systems. These categories and themes were confirmed with the researcher's supervisors.

Lewis (2012:8) opines that all the categories or themes should be examined to identify any patterns or inconsistencies. "The interpretation of the collected data may be considered as the craft for giving its own meaning to the reassembled data" (Yin, 2011:207). The author adds that "the goal of interpretation is to develop a comprehensive interpretation, while still encompassing specific data". From the data analysis the components for the clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery were identified based on consensus reached during the workshop during Phase 1.

3.3.4.4 Representing the data analysis

The results of the analysis should be represented in a summary form (view Table 4.1 for a summary of research findings). In qualitative research presenting the results may involve a discussion of the evidence and a presentation of a model or framework. For the purpose of this study, the results are discussed in detail in Chapter 4 and the model or framework will be the clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery in a private hospital in Gauteng.

The overall goal of this study was to develop a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery to improve the quality and standard of paediatric patient care, especially during and following cardiothoracic surgery. Lannon (2007:13) states the quality of care is “overall the degree to which healthcare services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge”.

Phase 2: Literature control

During Phase 2, the researcher conducted a literature control. During the literature control, the researcher took each component identified during the workshop and searched for confirmatory or contradictory literature pertaining to the identified components. The literature control is discussed in detail in Chapter 4.

Phase 3: Refinement phase

Phase 3 consisted of three steps. Step (1) developing a draft clinical pathway for the extubation of the mechanically paediatric patient following cardiothoracic surgery. Step (2) refinement with participants (3) refinement with experts and developing a final clinical pathway for the extubation of the mechanically paediatric patient following cardiothoracic surgery, refer to Section 4.9. Refinement process is discussed in Sections 3.3.5 to 3.3.7.

3.3.5 Developing a draft clinical pathway

Vanhaecht et al. (2010:117-118) opines clinical pathways are used all over the world as they ensure that clinical care is based on the latest research. Clinical pathways are also known as critical pathways, integrated care pathways or care maps (Vanhaecht, et al., 2006:529).

In Chapter 4 the researcher explained the data collected from the workshop and confirmed the relevant data with recent literature. Several aspects of the identified weaning and extubation criteria pertaining to all five body systems were not elaborated on, or even mentioned, in literature. The sub-categories not sufficiently mentioned or described in literature are listed below.

- **Central nervous system:** pupils reactive to light
- **Cardiovascular system:** Venous access in situ and chest tubeage less than 30-50 ml/24hrs
- **Respiratory system:** bilateral air entry on auscultation
- **Renal system:** normal urine dipstick
- **Gastrointestinal system:** absorption of feeds

Hence, these sub-categories were not included in the draft clinical pathway. Furthermore, under the respiratory system the normal pH levels were not consented upon during the workshop, but the researcher found several references in the literature pertaining to pH as part of weaning and extubation criteria; thus, pH was included in the draft clinical pathway.

The draft clinical pathway was developed by the researcher based on the evidence collected. A few attempts were made to decide which pathway would be most appropriate and easy to use in the relevant paediatric CCU (PCCU). Refer to Annexure C1 for an example of the draft clinical pathway. This was the specific draft example given to the experts.

3.3.6 Refinement by participants

The draft clinical pathway for the extubation of the mechanically ventilated paediatric patient was then handed back to the participants for validation. They were requested by the researcher to make necessary alterations in writing on the draft clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery. The nine participants were suggested satisfied with the draft clinical pathway and no alterations were made.

3.3.7 Refinement by experts

Following the refinement from the participants, the researcher sampled experts in the field of paediatric critical care by the use of purposive sampling. These experts included seven specialists, (refer to Table 3.3). In the specific PCCU there were five paediatricians who specialised in mechanical ventilation. Two of these experts consented to participate in this study. Using the same sampling method, the researcher sampled two anaesthetists, of whom one specialised as an intensivist. They both consented to participate in this study. The researcher used purposive sampling to sample a general surgeon whom has specialised as an intensivist. He [the expert] did not consent to participate in this study. Thus four experts consented to participate in this study.

The draft clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery was handed to each expert for refinement. Each expert willingly signed a consent form to participate in this study, (refer to Annexure B1). The researcher requested from each expert to make alterations in writing on the clinical pathway. Refer to Table 3.3 for a summary of the expert suggestions on the draft clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery.

Table 3.3: Summary of expert suggestions on draft clinical pathway

Experts	Responded	Suggestion
Anaethetist/intensivist	Yes	Nil
Anaethetist	Yes	Expert included the listed articles via e-mail for further reference: • Bauman, & Hyzy, 2012. *Extubation management*. January:1-14 • Epstein 2010: *Weaning from mechanical ventilation: readiness testing.*
Pulmonologist	No	
General surgeon/intensivist	No	

Experts	Responded	Suggestion
Paediatrician	Yes	Nil
Paediatrician	Yes	Nil
Paediatrician	No	

The researcher was then able to develop a final clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery. Refer to Annexure C2.

3.4 TRUSTWORTHINESS

In qualitative research trustworthiness indicates a methodological soundness and adequacy of the study. Researchers make judgments of trustworthiness possible through developing dependability, credibility, transferability and confirmability (Holloway & Wheeler, 2002:254; Polit & Beck, 2006:511). Trustworthiness is another focal virtue for nurses and is measured by others' recognition of the nurse's consistency and predictability in following moral norms (Burkhardt & Nathaniel, 2002:36). Trustworthiness also applies to the researcher as regards the measuring of consistency and foreseeing the significance of the presented data.

An important component of good research is a report of the validity of the data and the results. Porter (2007:83) states validity entails nurses to be confident that the information they use is sufficiently accurate in order to ensure that their practice is appropriate. It is the opinion of Reynolds et al. (2011:7) that quality assurance during qualitative studies includes triangulation, member checking and peer review. The first approach is triangulation where the researcher builds evidence from several sources or from various individuals. In this study several members of the multidisciplinary team were used as participants, namely, critical care registered nurses, a physiotherapist and experts. All the collected information was correlated and confirmed or contradicted with recent literature.

During qualitative studies member checking is a frequently used approach in which the researcher takes the summaries of the findings back to the key study participants and asks them whether the findings are an accurate reflection of their experiences. For the purpose of this study the final clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery was taken back to all the study participants to validate. A peer review was done and is described in Table 3.1. The peer review added more dependability to the study and provided a clearer picture of the credibility of the participants.

3.4.1 Credibility

According to Polit and Beck (2006:332), credibility refers to "confidence in the truth of the data and interpretations of them". Strőmberg (n.d.:n.p.) states credibility includes a description of the data collection method and data analysis. Credibility deals with the question, "how congruent are the findings with reality?" (Shenton, 2004:64). Triangulation is one method that can be used to ensure a study is more credible; trustworthiness is perceived as the use of multiple referents to draw conclusions about what constitutes the truth (Shenton, 2004:65; Polit & Beck, 2006:333).

Several ways of triangulation were used in this study as data source triangulation. Data source triangulation entails the use of multiple data sources; in this study it included a literature review and a workshop. Investigator triangulation is conducted by using more than one expert to collect and interpret data. Eight critical care registered nurses, one physiotherapist and four experts within the clinical field participated in the current study. As members of the multidisciplinary every one of these participants provided a different perspective on the phenomenon; although diverse, each participants' knowledge, skills and experience complemented the others' which advanced the validity of the study.

3.4.2 Dependability

According to Holloway and Wheeler (2002:255), if the findings of a study are to be dependable, it must be consistent and accurate. If the same study was to be repeated in the same context with the same methods and with the same study participants and similar results are obtained, then the study is dependable (Shenton, 2004:71). A dense description of the research method has to be included and any inconsistency during data collection and data analysis should be described (Strőmberg, n.d.:n.p.). The research methods used for this study are described in Section 3.3. The collected data are described in detail in Chapter 4 and all contradictory information indicated. The setting of the research must also be described in detail and to achieve some measure of dependability an audit trial is necessary. The setting of this research is described in depth in Section 3.2.2.

3.4.3 Confirmability

Confirmability is defined as "the potential for congruence between two or more independent people about the data's accuracy, relevance, or meaning" (Polit & Beck, 2006:336). In the view of Burns and Grove (2009:539), confirmability refers to objectivity, that is, the potential for correspondence between two or more independent people about the data's accuracy, relevance, or meaning. This criterion is concerned with ascertaining that the data represents the information the participants provided truthfully and completely, and that the interpretations of this data are not fabrications of the researcher's imagination. The findings from the brainstorming session during the workshop ensured confirmability in view of the fact that the information was verified by the participants and the researcher's supervisors (supervisors both with more than ten years research supervision experience). During the workshop the study participants reached consensus on the collected data, thus further confirming the correctness of the collected data.

3.4.4 Transferability

As agreed by Polit and Beck (2006:768) and Shenton (2004:69), transferability is the extent to which qualitative findings can be transferred to other settings or groups (refer to Section 1.6). Morse (1994:105) mentions the goal of qualitative research is not to produce generalisation, but rather an in-depth understanding and knowledge of a particular phenomenon. It is the responsibility of the researcher to establish whether the criteria can be met in a similar context while preserving the original particular findings from a study. A rich description of the research content and assumptions should be given (Strőmberg, n.d.:n.p.). Refer to Section 1.8.4 for the assumptions of this study.

3.4.5 Authenticity

Authenticity is the extent to which qualitative researchers fairly and faithfully show a range of different realities in the analysis and interpretation of their data (Polit & Beck, 2006:748). Authenticity indicates that the study is reliable or trustworthy (Thomson, 1996:49). The researcher collaborated with 13 experts (8 critical care registered nurses, 1 physiotherapist and 4 experts) in the field of mechanical ventilation and extubation of the paediatric patient following cardiothoracic surgery. This enabled the researcher to ascertain and confirm the components of the clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery.

3.5 ETHICAL CONSIDERATIONS

A concept which was of utmost importance was that the rights of the participants were acknowledged and protected while the current study was conducted. Ethical concerns are "especially prominent in nursing research because the line of demarcation between what constitutes the expected practice of nursing and the collection of research information can sometimes get blurred" (Polit & Beck, 2008:167). Ethics is defined as "a system of moral values that is concerned with the degree to which research procedures adhere to professional, legal, and social obligations to the study participants" (Polit & Beck, 2008:753). In order to protect the study participants, there were certain procedures followed which are discussed in Sections 3.5.1 to 3.5.5.

Dreyer et al. (1997:9) state ethics can be described as values that govern the behaviour of a group or the researcher. This study was conducted in an ethical, accurate, evidence-based manner. The researcher must further persist in being vigilant throughout the implementation of the research plans since ethical dilemmas may arise during the study (Polit & Beck, 2008:185).

3.5.1 Informed consent and participant authorisation

According to Henning et al. (2004:73), the participants must give informed consent before participating in any research study. The informed consent forms were signed during Phase 1 and Phase 2 by all the participants (refer to Annexures B1). Polit and Beck (2008:176) state the importance of safeguarding participants and protecting their right to self-determination by obtaining their informed consent. These authors add that informed consent further indicates that the participants have received adequate information regarding the research study and it is their free choice to make their own decision as to whether they agree and want to participate or not.

In the current study written informed consent was obtained from all the participants (refer to Annexures B1).The researcher shared the following information regarding the study with each participant in the written consent document: the study title, goals and objectives, the type of data needed from the participants and a description of the data collection procedures. The nature of the participant's commitment was stated and the potential benefits and risks relating to participation were discussed. A confidentiality pledge was included, voluntary consent was explained and the contact information of the researcher was provided to the participant (refer to Annexure B1 for the informed consent forms given to all the participants prior to the data collection processes).

3.5.2 Confidentiality procedures

According to Oliver (2010:77), the cornerstone in research ethics is that participants have the right to anonymity. Anonymity involves that the identity of all the participants is untraceable and hidden in the research report (Oliver, 2010:77). In this study no study participant's names or identities were mentioned or made available. The researcher kept all written documents locked away and nobody else had access to it except the researcher herself. The demographic data of all the participants were described without making their identities known or public (refer to Table 3.1 and Table 3.3). The participants were referred to as *critical care registered nurses, physiotherapists, experts or members of the multidisciplinary team.*

Confidentiality is another right of the participant and entails privacy (Oliver, 2010:81). Before signing the informed consent form, the researcher discussed and assured the specific participant that his or her confidentiality would be maintained during the study process as well as after the study had been completed (Oliver, 2010:82).

3.5.3 Debriefings and referrals

The researcher was always gracious and polite, sensitive to cultural and linguistic diversity and phrased questions tactfully (Polit & Beck, 2008:182). She made a point of being available at all times to answer any questions the study participants might have had or to listen to complaints and inputs from the participants. Her contact information was given to each participant in the invitation and the consent form (refer to Annexures B1). The researcher further shared the study findings with all the study participants once the data had been analysed.

3.5.4 External reviews and the protection of human rights

This study was reviewed and approved by the Research Ethical Committee of the relevant university. This process was followed to establish that all ethical requirements were adhered to during the conduction of this study. Researchers are not always objective in assessing the risk/benefit ratios or in the development of procedures to protect participant rights (Polit & Beck, 2008:184).

3.5.5 Building ethics into the design of the study

“Researchers must persist in being attentive throughout the implementation of the research plans for any unforeseen ethical dilemmas that may arise during the study” (Polit & Beck, 2008:185). The data collection and recording were done diligently and accurately throughout the study in order to assure evidence-based research was conducted. Data analysis is essential and was done with accuracy and care was taken not to exclude important information. This study was conducted in an ethical, accurate, evidence-based manner.

3.6 CONCLUSION

In Chapter 3 the research design and methods which were specifically applicable to this study was discussed. In Chapter 4 the researcher discusses the research findings and the development of a final clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiovascular surgery in a private hospital in Gauteng.

4 RESEARCH FINDINGS AND LITERATURE CONTROL

"A man should look for what is, and not for what he thinks should be"
-Albert Einstein (1879-1955)-

4.1 INTRODUCTION

In Chapter 3 the researcher described the research methodology relevant to this study. In Chapter 4 the research findings and literature control are discussed in detail. The researcher utilised five themes namely assessment, planning, implementation, evaluation and documentation in accordance with the nursing process.

4.2 PHASE 1: COMPONENTS OF THE CLINICAL PATHWAY AND PHASE 2: LITERATURE CONTROL

During Phase 1 of this study the researcher facilitated a workshop where the study participants brainstormed, data were collected and consensus reached by all participants. (Refer to Section 3.3.1-3.3.4). The researcher developed a draft clinical pathway from all the identified criteria (refer to Annexure C1). As mentioned in Section 1.1, weaning and extubation protocols present with three components: a list of the criteria to assess readiness to wean from mechanical ventilation, guidelines to reduce ventilatory support, and a list of extubation criteria. The researcher developed a clinical pathway based on these three components.

During the workshop and the development of the draft clinical pathway, the nursing process was utilised as the conceptual framework. According to Barnes Bolander (1994:110), the nursing process forms the foundation for nursing practice and research. The nursing process is a series of planned steps and actions directed at solving problems (Barnes Bolander, 1994:110). Novieastari (n.d.:n.p.) states the nursing process enables the nurse to organise and deliver nursing care. It is the opinion of Lilley, Lane, Aucker and Albanese (1996:7) that the nursing process is an organisational framework for the practice of nursing; this process is central to all nursing actions. According to Yildirim and Őzkahraman (2011:259), the nursing process provides the basis for critical thinking skills. Critical thinking includes knowledge, skills and attitude and incorporates the nursing process and problem-solving approach; moreover, the nursing process is useful because it encourages uniformity in practice (Yildirim & Őzkahraman, 2011:257-258).

The nursing process consists of the following five themes: assessment, planning, implementation, evaluation, and documentation. An in-depth discussion of each theme is presented in Sections 4.3 to 4.6. Under each theme a category was identified namely the neurological, cardiovascular, respiratory, renal and gastrointestinal systems. Each category is discussed in detail under each theme. Further sub-divisions were made and named sub-categories. These sub-categories were explored and supported or contradicted with literature. An overview of the research findings is given in Table 4.1.

Table 4.1 Summary of research findings

Theme	Category	Sub-category
Assessment	**Neurological system**	Awake and responsive
		Pupils reactive to light
		Pain free
		Cough and swallow reflexes present
	Cardiovascular system	Haemodynamically stable according to age parameters
		Venous access in sito
		Chest tube drainage less than 30-50 ml/24hrs
		Haemoglobin more than 10 g/dL
	Respiratory system	Spontaneous breathing at rate normal for age
		Bilateral air entry present on auscultation
		Not excessive secretions
		Saturation above 90%
		No signs of laboured breathing
		PaO_2 above 70 mmHg
		$PaCO_2$ 35-40 mmHg
		Lactate less than 2 mmol/L

Theme	Category	Sub-category
Assessment	**Renal system**	Urine output 0.5-1 ml/kg/hr
		No abnormalities detected using urine dipstick testing
	Gastrointestinal system	No abdominal distention
		Absorption of feeds
		Abnormal bowel sounds present on auscultation
		Blood glucose 3.5-5 mmol/L
Planning	**Ventilator settings**	Mode: CPAP
		Pressure support: less than 8 cmH_2O
		PEEP: 5cmH_2O
		FiO2: 0,4
	Equipment for extubation	Suction equipment
		Humidifier
		Oxygen connection
		Flow meter
		Nebulizer with prescribed medication
		Emergency trolley
		Nasal cannulae
		Pulse oximeter
		Mechanical ventilator
		Bag valve mask
Implementation	**Extubation**	Removal of endotracheal tube
Evaluation	**Neurological system**	Awake and responsive
		Comfortable
	Cardiovascular system	Haemodynamically stable according to age parameters
	Respiratory system	Chest X-ray normal
		No laboured breathing present
		Saturation above 90%
		Normal lung sounds on auscultation
	Renal system	Urine output 0.5-1 ml/kg/hr
	Gastrointestinal system	Normal bowel sounds on auscultation

The researcher found a lot of literature on the adult patient, but literature that referred to the paediatric patient was scanty (refer to Section 2.3.6). According to Ascano (n.d.:n.p.), paediatric literature is scant and no consensus is available. Thus during this chapter the researcher refers to the mechanically ventilated patient and not to the mechanically ventilated paediatric patient, although all the utilised literature may still be related to the paediatric patient. It is the opinion of Hita (2011:328) that there is a symbiosis between adult and paediatric critical care as paediatric critical care medicine have absorbed the experience of adult CCUs, modifying and adapting the protocols. In Section 4.3, Theme 1 assessment is discussed.

4.3 THEME 1: ASSESSMENT

Theme 1 was derived from the nursing process used as conceptual framework for this study (refer to Section 1.8.5). During the assessment phase information about the patient was collected which included the physical and psychosocial status of the patient (Wright, 1994:110). It is the opinion of Barnes Bolander (1994:110) that data are obtained by observation, physical assessment and reviewing the medical records. Novieastari (n.d.:n.p.) describes the assessment phase as the systemic collection, verification, analysis and communication of the patient's data. According to Smeltzer et al. (2010:661), careful assessment is required to determine whether the patient is ready to be removed from mechanical ventilation.

The categories derived from the group discussion were the neurological, cardiovascular, respiratory, renal and gastrointestinal systems. Each category is discussed comprehensively in Section 4.3.1 to 4.3.5. Several sub-categories were identified under each category and are explained. During the workshop, the researcher asked the following questions under the assessment phase:

- "When you look at the paediatric patient following cardiothoracic surgery what do you need to see to assess extubation readiness?"
- "When you physically examine the paediatric patient following cardiothoracic surgery what are you looking for to assess extubation readiness?"
- "What will be your goals with specific mechanical ventilator settings in order to finally extubate the paediatric patient?"

4.3.1 Neurological system

The neurological system consists of the brain, spinal cord and nerves (Potts & Mandleco, 2007:1053). According to Martin (2010:495), the neurological system is a vast network of cells specialised to carry information to and from all body parts in order to bring about bodily activity.

Two authors who state the neurological system is important as part of extubation criteria are Sifain and Papadakos (2011:31). Contradictory to their statement is the opinions of Epstein (2009:40) and Wendell and Kofke (2011:1) that the neurological status as a predictor of extubation failure has produced contradictory results.

During the workshop, four sub-categories were named by the study participants under the neurological system, namely: awake and responsive, pupils reactive to light, pain free and cough and swallow reflexes should be present. Each sub-category is discussed next with supportive and/or contradictive literature where the latter is applicable. After each discussion, a summary will be given in tabulated form (refer to Table 4.3.).

4.3.1.1 Awake and responsive

During the workshop the following inputs were given by the participants in response to the neurological assessment of the paediatric patient.

- "Patient should respond to stimuli"
- "Awake, alert, tolerates interaction"
- "Is the child awake, opens both eyes spontaneously"

According to Gatiboni, Piva, Garcia, Jonhston, Hommerding, Franz and Gualdi (2011:200), the required general conditions for extubation are that the patient should be alert and awake with or without minimal sedatives and analgesic infusion. Sifain and Papadakos (2011:31) and Skillings and Curtis (2011:44) agree that examples of extubation criteria include the neurological system are that the patient should be awake and should be able to follow commands. Ahmed, Naveed, Khan, Faridullah, Zahoor, Mahrukh, Badar-ul-Samad, Rafique, Muhammad, Faisal, Muhammad, and Sikander (2010:29) and Singh, Choudhary, Singh, and kumar (2011:86) emphasise that extubation may be attempted when the paediatric patient is alert.

Additionally, Robertson (2007:3) asserts that the patient should be able to cooperate before extubation. More authors who confirm that an adequate conscious level is required for airway maintenance is Lermitte and Garfield (2005:1) and York Clark (2009:50). It is stated by Vidotto, Sogame, Gazzotti, Prandini and Jardim (2011), Bauman and Hyzy (2012:2) and Maung and Kaplan (2012:15) that a Glascow coma scale (GCS) equal to or greater than 8 out of 15 is sufficient to wean the mechanically ventilated patient from mechanical ventilation. This statement is, however, contradicted by Ascano (n.d.:n.p.) stating that the GCS should be above 13 out of 15 for the mechanically ventilated patient to be extubated. Martin (2010:307) "defines the GCS as a numerical system used to estimate a patient's level of consciousness after head injury". Anderson, Anderson and Glanze (1994:673) describes the GCS as a practical and standardised system for assessing the degree of consciousness in the critically ill patient. The GCS includes eye opening response, best motor response, and best verbal response (Rosman, 2006:731). No mention is made about by this author about pupil response in the GCS. For the purpose of this study consensus was reached that a GCS above 10 out of 15 was an acceptable guideline.

4.3.1.2 Pupils reactive to light

The following quoted answers from the participants were received:

- "Pupils equal and reactive"
- "Pupils reactive"
- "Pupils reacting to light"

The pupil of the eye is characteristically round, regular and the same in size and has a response to light in both eyes (Smeltzer & Bare, 1996:1593). A definition of light reflex is given by Anderson et al. (1994:911) as the mechanism by which the pupil of the eye constricts in response to direct stimulation with light. It is the opinion of Monahan, Neighbors, Green, Sands and Marek (2007:307) that pupillary response is part of the neurological assessment of the post-operative patient.

The only reference to pupillary response before extubation found in literature by the researcher included Rosman's (2006:731) description of the GCS. Reference is made to neuro-ophtalmologic evaluation after head injury but the cardiothoracic patient is not mentioned. Rosman (2006:732) further states after head injury the evaluation should include pupillary size and reactivity – this evaluation may be applicable to the cardiothoracic patient, but no literature to confirm it was found by the researcher. Similarly, the researcher could not find much literature on pupillary response related to extubation. Several sources were consulted by the researcher in an attempt to find information pertaining to extubation and pupillary response. These sources, pertaining to paediatric as well as adult authors' work, are reflected in Table 4.2.

Table 4.2 Consulted resources on pupil reaction

Sources	Consulted authors	
	Paediatric authors	**Adult authors**
Articles / books	• Ascano (n.d.:n.p.) • Gatiboni et al. (2011) • Singh et al. (2011) • Johnston, de Carvalho, Piva, Garcia, and Fonseca (2010) • Saharan, Lodha and Kabra (2010) • Rosman (2006)	• De Groot, Dekkers, Herold, de Jonge, and Arbous (2011) • Sifain and Papadakos, (2011) • Ahmed et al. (2010) • Sena and Nathens (2010) • Vidotto et al. (2011) • Karmarkar and Varshney (2008) • Hemant, Chacko and Singh (2006) • Lermitte and Garfield (2005)
Policy / protocol		• Putney, Burgman, Kirchman, and Olsen, (2011) • Robertson (2007) • Union hospital (n.d.)
University library	Librarian consulted for search: Librarian used Medline	Librarian consulted for search: Librarian used Medline
Other sources consulted: Key words: pupil reaction as extubation criteria after (paediatric) heart surgery	Researcher: Pubmed and PDF articles	Researcher: Pubmed & PDF articles

4.3.1.3 Pain free

The participants confirmed that the paediatric patient should be pain free as evidenced by the following quotes that emerged during the workshop.

- "Patient should be pain free"
- "Patient must be restful, not agitated"
- "Calm"

Pain may influence patient recovery and may also cause rapid, shallow breathing and a hesitancy to cough which, in turn, may lead to stasis of pulmonary secretions (Monahan, et al., 2007:323; Schechter 2007:1388). Weisman and Rusy (2006:436) observe that "pain is a complex constellation of unpleasant sensory, perceptual, and emotional experiences and associates with autonomic, psychological, emotional and behavioural responses". According to Smeltzer and Bare (1996:181) and Nair and Neil (2013:1), pain can affect the pulmonary, cardiovascular, gastrointestinal, endocrine, and immunologic systems. This statement is confirmed by Fawaz and Fahmy (2011:79) who indicate that inadequate analgesia may lead to many haemodynamic, respiratory, immunologic, metabolic and haemostatic alterations such as tachycardia, tachypnoea, impaired immune response, and an increased catabolism and platelet activation. A stress response can occur with pain, leading to an increased metabolic rate, increased cardiac output, impaired insulin response and increased retention of fluids (Smeltzer & Bare, 1996:181) (refer to Section 2.3.5).

It is stated by Burns (2011:292) that, in order to extubate the mechanically ventilated patient, his or her pain should be under control. It is stipulated in the weaning and extubation protocol of the Union hospital (n.d.:n.p.) that the patient should be kept comfortable and pain free; however the protocol cautions that sedative and analgesic administration should be kept at a minimum. Lermitte and Garfield (2005:2) and Fawaz and Fahmy (2011:79) concur that appropriate analgesia properly administered according to the doctor's instructions is one of the general preconditions for commencement of weaning the patient from mechanical ventilation.

4.3.1.4 Cough and swallow reflexes

The following quotes are evidence that the participants were aware that, as concerns the neurological system, the cough and swallow reflexes of the patient was important as part of the extubation criteria.

- "Muscle tone/power"
- "Patient must be awake, able to cough and swallow"
- "Normal reflexes" [cough and swallow reflexes]

Ascano (n.d.:n.p.) and De Souza, Cordeiro, Guimarães, Fernando, Silva and Lugan, Jocemir (2013:2) determines that a cough and gag reflex should be part of the policy for the extubation of the mechanically ventilated patient. Saharan, Lodha and Kabra (2010:1300) and El-Bayomi, El-Refaey, Abdelkader, El-Assmy, Alwakeel and El-Tahan, (2011:3) confirm that the airway reflexes should be intact when considering the patient for extubation. An article by Sifain and Papadakos (2011:31) states examples of extubation criteria include good reflexes and the ability to maintain or his own airway; this statement is confirmed by Maung and Kaplan (2012:15) who note that patients should "be able to protect their own airway and be able to clear their own secretions". Bauman and Hyzy (2012:1) define airway protection as the ability to guard against aspiration during spontaneous breathing.

The patient criteria for extubation include a good spontaneous cough (Lermitte & Garfield, 2005:2; Sena & Nathens, 2010:8; Skillings & Curtis, 2011:44) A weak cough is associated with an unsatisfactory airway and extubation failure (Wendell & Kofke, 2011:1). Daily screening criteria for extubation, including that the mechanically ventilated patient should be able to cough on demand or have a good cough reflex during endotracheal suctioning, is part of the weaning and extubation protocol of the Union hospital (n.d.:n.p.). More confirmation of a cough reflex as part of extubation criteria is given by Robertson (2007:3). According to Macht et al. (2011:4), dysphagia is associated with pneumonia, re-intubation and in-hospital mortality. In Table 4.3 a summary of the neurological system, its sub-categories and supportive authors are given.

Table 4.3: Assessment of neurological system

Category	Sub-category	Supportive authors	
		Paediatric authors	Adult authors
Neurological system	**Awake and responsive**	• Ascano (n.d.:n.p.) • Gatiboni et al. (2011:200) • Singh et al. (2011:86) • Rosman (2006:731)	• Maung and Kaplan (2012:15) • Sifain and Papadakos (2011:31) • Skillings and Curtis (2011:44) • Ahmed et al. (2010:29) • York Clark (2009:50) • Robertson (2007:3) • Lermitte and Garfield (2005:2)
	Pupils reactive to light		• Monahan et al. (2007:307)
	Pain free	• Schechter (2007:1388)	• Burns (2011:292) • Fawaz and Fahmy (2011:79) • Monahan et al. (2007:850) • Lermitte and Garfield (2005:2) • Union hospital (n.d.:n.p.);
	Cough and swallow reflex	• Ascano (n.d.:n.p.) • El-Bayoumi et al. (2011:3) • Saharan, Lodha and Kabra (2010:1300)	• De Souza et al. (2013:2). • Maung and Kaplan (2012:15) • Sifain and Papadakos (2011:31) • Skillings and Curtis (2011:44) • Wendell and Kofke (2011:1) • Sena and Nathens (2010:8) • Robertson (2007:3) • Lermitte and Garfield (2005:2) • Union hospital (n.d.:n.p.)

- **Conclusion**

Sufficient literature on the patient to be "awake and responsive" is available, thus confirming the importance of the mechanically ventilated patient being awake and cooperative. The researcher found literature on pain control, cough and swallow reflexes, but very little literature were found on pupillary responses when the patient is considered for extubation. The researcher is of the opinion that further research is needed on the importance or possible insignificance of pupillary response when extubating the mechanically ventilated patient.

4.3.2 Cardiovascular system

According to Potts and Mandleco (2007:753), the heart is the symbol for love, emotion and mortality. Martin (2010:115) states the cardiovascular system affects the circulation of blood, which transports nutrients and oxygen to the tissues and removes waste products, throughout the body.

Pathophysiology in paediatric heart disease is variable and challenging to even the most experienced clinician (Potts & Mandleco, 2007:753). Sifain and Papadakos (2011:31) include the cardiovascular system as part of extubation criteria. During the workshop four sub-categories were identified by the participants namely haemodynamic stability, venous access to be in situ, chest tube drainage should be less than 30-50 ml/24hrs and haemoglobin should be more than 10 g/dL.

All four sub-categories are discussed in detail in Sections 4.3.2.1-4.3.2.4. Supportive literature is presented and, where obtained, contradictory literature is included. .

4.3.2.1 Haemodynamically stable

The following quotes from the participants during the workshop support the fact that the patient had to be haemodynamically stable for extubation to be considered:

- "Vital data within normal limits, for example, apyrexial, sinus rhythm, blood pressure normal."
- "Haemodynamically stable"
- "Blood pressure and pulse within normal range for age"

According to Top, Tasker, and Ince (2011:1), haemodynamic monitoring is the cornerstone of critical care. Also stated by Top et al. (2011:1) is that paediatricians should be familiar with age-appropriate normal values and the physiological differences between adults and children (refer to Tables 2.4 and 2.5).

De Groot et al. (2011:3), Nery, Pastore, Carvalho, Roberto, Ribeiro, Schettino and Guilherme (2011:761) and de Souza et al. (2013:2) conclude that criteria to wean and extubate the mechanically ventilated patient should include haemodynamic stability. Sifain and Papadakos (2011:31) state under the cardiac system the patient should be stable, without mechanical support such as an intra-aortic balloon pump, and no serious arrhythmias should be present. Singh et al. (2011:86) also agree that extubation may be attempted if the patient is haemodynamically stable while Wendell and Kofke (2011:1) mention that extubation may be considered once the patient is not haemodynamically compromised.

Ahmed et al. (2010:28) state haemodynamic instability prolongs mechanical ventilation in the cardiothoracic surgery patient. More articles in support of this statement were found in scientific research articles from Saharan, Lodha and Kabra (2010:1300), Sena and Nathens (2010:8) and Vidotto et al. (2011:2). The weaning and extubation protocol of Union hospital (n.d.:n.p.) determines in order to extubate the mechanically ventilated patient, he or she should be haemodynamically stable with no inotropic support except for a low dose of Dobutrex. Robertson (2007:3) confirms this statement by indicating that the patient should be haemodynamically stable with low doses of inotropes. The fact is, as Mittnacht et al. (2008:92) point out, patients requiring high doses of inotropic support are usually too haemodynamically unstable to allow for safe extubation. Martin (2010:378) explains that inotropes such as Dobutrex affect the contraction of the heart muscle; it stimulates it to contract thus increasing the heart rate.

According to Top et al. (2011:1), the adequacy of circulatory stability is judged by parameters such as blood pressure, urinary output, heart rate and serum lactate concentration. Specific values and volumes were not mentioned in this article, but it can be concluded that optimal urinary output and normal lactate levels are important factors in haemodynamic stability and can therefore be connected to weaning criteria (also refer to Sections 4.3.3.8 and 4.3.4.1). This statement is further confirmed by Lucas and Ginsberg's (2003:407) assertion that the primary determinant of post-operative survival is cardiac output, which is estimated by physical examination, and by measuring acid-base status and urinary output. In order to monitor cardiovascular stability, the patient is assessed for mental status, vital signs, cardiac rhythm, skin temperature, skin colour and urinary output (Smeltzer, et al., 2010:464).

Body temperature was not mentioned much during the workshop, but is described in literature as part of the weaning criteria and it can be related to the patient's haemodynamic status. Burns (2011:292), Putney et al. (2011:1), Sifain and Papadakos (2011:31) and Ascano (n.d.:n.p.) are all in agreement with the Union hospital's weaning and extubation protocol (n.d.:n.p.), namely, that the paediatric patient should be normothermic before she or he can be weaned from mechanical ventilation and extubated. Black and Hawks (2005:1894) and Hemant, Ryan and Singh (2006:435) concur that the patient should be afebrile when considered for extubation from mechanical ventilation.

It is the opinion of Epstein (2010:3) that hyperthermia increases respiratory load while Saleh and Barr (2005:173) note hypothermia has negative effects on the haemodynamic, immune and metabolic status of the paediatric patient. Hypothermia causes shivering, increasing myocardial workload, oxygen demand and lactic acid production (Monahan, et al., 2007:850). According to Gonçalves, Honrado, Winck, João, Carlos and Paiva (2012:2), the body temperature should be less than 38° Celsius in order to extubate the mechanically ventilated paediatric patient. In Table 4.4 the normal body temperature according to age are summarised.

Table 4.4: Normal body temperature according to age

Age	Temperature centigrade
Newborn	37.5-37.7
1 year	37.5-37.7
3 to 5 years	37.0-37.2
7 to 9 years	36.7-36.8
10 years and older	36.6

(Source: Potts and Mandleco, 2007:391)

4.3.2.2 Venous access

The participants referred to the importance of venous access which should be in situ for easy intravenous access for the extubation of the mechanically ventilated paediatric patient:

- "IV [intravenous] weaned to minimal"
- "All lines must be patent"
- "Drip functioning well"

Burns (2011**:**292) mentions that the patient should be systemically hydrated when extubation is considered. According to Monahan et al. (2007:307), part of post-operative nursing and the systematic approach to assessment is the assessment of venous access patency. Fluid volume deficits require fluid replacement after major surgery. In fact, most patients receive intravenous fluids to maintain fluid and electrolyte balance (Monahan, et al., 2007:232,323). Greenbaum (2011:124) states that children may require concurrent replacement of fluids via intravenous administration. Smeltzer and Bare (1996:236) and Geyer, Mogotlane and Young (2011:476) summarise the purpose of intravenous fluid therapy as follows:

- to provide water, electrolytes, and nutrients to meet daily requirements
- to replace water and correct electrolyte deficits
- to provide a medium for intravenous administration of medications
- to provide access to the circulation in case of emergency.

These statements all indicate the possible importance of venous access patency when the post-surgical patient is considered for extubation from mechanical ventilation, but no direct reference was made to venous access patency and extubation. Saharan, Lodha and Kabra (2010:1300) point out that no association has been shown between cumulative fluid balance and the duration of mechanical ventilatory weaning or extubation outcomes in paediatric patients.

The statement of Gatiboni et al. (2011:200) that while the mechanically ventilated patient is being weaned from mechanical ventilation, he or she may still require minimal infusion of sedatives and analgesia furthers the argument that venous access is essential. Several sources of literature were consulted by the researcher in an attempt to find confirmation in literature that venous access is to be considered as part of weaning and extubation criteria. The consulted sources are shown in Table 4.5 next.

Table 4.5: Consulted resources on venous access

Sources	**Consulted authors**	
	Paediatric authors	**Adult authors**
Articles/books	• Gatiboni et al. (2011) • Singh et al. (2011) • Top et al. (2011) • Johnston et al. (2010) • Saharan, Lodha and Kabra (2010)	• De Groot et al. (2011) • Sifain and Papadakos (2011) • Ahmed et al. (2010) • Sena and Nathens (2010) • Vidotto et al. (2011) • Hemant, Chacko and Singh (2006) • Lermitte and Garfield (2005)
Protocols/policy		• Putney et al. (2011) • Robertson (2007) • Union hospital (n.d.)
University library	Librarian consulted: Used Medline	Librarian consulted: Used Medline
Other sources consulted: Key words: iv access as extubation criteria after (paediatric) heart surgery	Researcher: Pubmed and PDF articles	Researcher: Pubmed and PDF articles

4.3.2.3 Chest tube

During the workshop the following quotes regarding chest tubes emerged.

- "No bleeding from mediasternal tubes"
- "No bleeding"
- "Chest tube drainage should be less than 50 ml/24hrs"

Shalli, Shanaz, Saeed, Diyar, Fukamachi, Kiyotaka, Marc, Cohn, Perrault and Boyle, (2009:503) note that post-operative drainage of surgical sites is a standard procedure with many operations; it is employed routinely following cardiothoracic surgery. Paarmann et al. (2012:3) ascertain that chest tube drainage should be less than 100 ml/hr. Dalfino, Sicolo, Paparella, Domenico, Mongelli, Rubino, Giovanni and Brienza (2013:2) is of the opinion that chest tube drainage should not exceed 10ml/hr for 4hrs.

During the workshop the participants reached consensus that the volume of chest tube drainage as part of the weaning criteria should be less than 30-50 ml/24hrs in the paediatric patient following cardiothoracic surgery. However, the researcher could not find confirmation of this in the literature. Karthekeyan et al. (2010:2) advise that in order to consider the mechanically ventilated patient for extubation acceptable chest tube drainage is to be considered.

According to Shann, Henning and Shekerdemian (2008:138), chest tube drainage in the paediatric patient should be less than 1-2 ml/kg/hr at 18-24 hours after surgery. When the chest tube drainage is less than 1-2 ml/kg/hr the drain can be removed on order of the cardiothoracic surgeon.

Minimal chest tube drainage of which the amount is not specified is mentioned by Brunelli, Beretta, Cassivi, Cerfolio, Detterbeck, Kiefer, Miserocchi, Shrager, Singhal, Van Raemdonck and Varela (2011:291) and Putney et al. (2011:1). A similar stance is taken by Refai, Brunelli, Salati, Xiumè, Pompili and Sabbatini (2011:1), namely that chest tube drain management is determined by habit and personal experience rather than scientifically valid information. Refai et al. (2011:1) base their view on the fact that there is scant information about the direct influence of chest tubes on patient symptoms and respiratory function. While Monahan et al. (2007:850) warn that excessive blood loss through the chest tubes may lead to hypovolaemic shock, Ahmed et al. (2010:28) state uncontrolled bleeding is an absolute contraindication to extubation following cardiothoracic surgery. Shalli et al. (2009:508) add that chest tube related pain increases the demand for post-operative analgesia and negatively affects the respiratory mechanism. Sources consulted by the researcher are listed in Table 4.6.

Table 4.6: Consulted resources on chest tube drainage

Sources	Consulted authors	
	Paediatric authors	**Adult authors**
Articles/books	• Karthekeyan et al. (2010) • Kanchi (2005)	• Dalfino et al. (2013) • Brunelli et al. (2011) • Refai et al. (2011) • Shalli et al. (2009)
University library	Librarian consulted: Used Medline	Librarian consulted: Used Medline
Researcher consulted cardiothoracic surgeon	Consulted cardiothoracic surgeon who provided information from Shann et al. (2008)	
Other sources consulted	Researcher: Pubmed and PDF articles	Researcher: Pubmed and PDF articles

4.3.2.4 Haemoglobin

As part of the evidence, quotes from the participants during the workshop with regard to the haemoglobin included:

- "Colour must be pink."
- "Hb [haemoglobin] more than 10 g/dL"
- "No anaemia/pallor"

Haemoglobin is a protein that binds easily to oxygen. Most oxygen carried in the blood is bound to haemoglobin (Marieb, 2004:648). Haemoglobin is a complex protein-iron compound in the blood that carries oxygen to the cells from the lungs and carbon dioxide away from the cells to the lungs (Anderson, et al., 1994:723). Urden, Stacy and Lough (2002:928) confirm that adequate haemoglobin levels are crucial to oxygen transport. In support, Hemphill (2011:1457) adds that an optimal level of haemoglobin in a healthy individual is adequate to meet the demand for oxygen.

Anaemia is a condition in which the blood has an abnormally low oxygen-carrying capacity. Further indicating the general importance of optimal haemoglobin levels, McLellan and Walsh (2004:1) state the main physiological responses to anaemia are increased cardiac output and increased oxygen demand.

Although sufficient information was found in literature that describes or expands on patients' haemoglobin levels in general, it does not elaborate on it as part of weaning and extubation criteria. It is noted by Saharan, Lodha and Kabra (2010:1300) that the haemoglobin level should be above 7 g/dL in children who are clinically stable. Ascano (n.d:n.p.) determines the normal haemoglobin levels in specifically children as between 8-10 g/dL. According to Hemant, Chacko and Singh (2006:435), Nery et al. (2011:761), as well as the weaning and extubation protocol by Union hospital (n.d.:n.p.), the haemoglobin level should be above 8 g/dL in order to successfully extubate the mechanically ventilated patient. Normal haemoglobin levels for adults are given by Hemphill (2011:1457) as between 12-17 g/dL. Lermitte and Garfield (2005:2) only state that haemoglobin levels should be "adequate" without informing what "adequate" implies. However, in her e-mail correspondence with regards to Epstein (2010:3), the researcher was informed that, to extubate the mechanically ventilated patient, the haemoglobin should be between 7-10 g/dL.

As described, controversies surrounding normal haemoglobin levels were encountered by the researcher in literature. To set a standardised level for haemoglobin levels to extubate the mechanically ventilated paediatric patient following cardiothoracic surgery, in the workshop the participants agreed that the paediatric patient's haemoglobin level should be above 10 g/dL. In Table 4.7 a summary of the cardiovascular system, the sub-categories and the supportive authors are given.

Table 4.7: Assessment: Cardiovascular system

Category	Sub-category	Supportive authors	
		Paediatric authors	Adult authors
Cardiovascular system	**Haemodynamically Stable**	• Singh et al. (2011:86) • Top et al. (2011:1) • Saharan, Lodha and Kabra (2010:1300)	• De Souza et al. (2013:2). • Gonçalves et al. (2012:2) • De Groot et al. (2011:3) • Nery et al. (2011:761) • Sifain and Papadakos (2011:31) • Wendell and Kofke (2011:1) • Ahmed et al. (2010:28) • Epstein (2010:3) • Sena and Nathens (2010:8) • Vidotto et al. (2011:2) • Robertson (2007:3) • Union hospital (n.d.:n.p.);
	Venous access/IV access	• Gatiboni et al. (2011:200) • Greenbaum (2011:124)	• Burns (2011:292) • Monahan et al. (2007:307)
	Chest tube drainage less than 50 ml/24hrs	• Not confirmed in literature	• Not confirmed in literature
	Haemoglobin (Haemoglobin) more than 10 g/dL	• Ascano (n.d.:n.p.)	• Hemphill (2011:1457) • Urden et al. (2002:928)

- ## Conclusion

Under the cardiovascular system the haemodynamic stability is elaborated on in literature, indicating the utmost importance thereof. It must be remembered that age specific parameters should always be taken into consideration when assessing the paediatric patient for extubation after cardio-thoracic surgery. Very little literature was found on venous access patency, chest tube drainage and haemoglobin levels as part of weaning and extubation criteria. The researcher believes that these aspects should be explored further.

4.3.3 Respiratory system

According to Potts and Mandleco (2007:707), the primary function of the respiratory system is to facilitate gas exchange in the body. The respiratory system is defined by Martin (2010:634) as a "combination of organs and tissues associated with breathing". Under the respiratory system, the eight sub-categories were identified by the participants. These categories include spontaneous breathing, bilateral air entry, no excessive endotracheal secretions, saturation above 90%, no signs of laboured breathing, PaO_2 should be between 35-40 mmHg and lactate should be less than 2 mmol/L. These categories will be discussed in detail in Sections 4.3.3.1-4.3.3.8.

No consensus was reached among the participants during the workshop as regards the acid-base (pH), but the researcher identified various references in the literature regarding the pH balance when considering the mechanically ventilated patient for extubation. For this reason, the researcher included a discussion on pH in Section 4.3.3.9.

4.3.3.1 Spontaneous breathing

Supportive quotes stated by the participants during the workshop included:

- "Breathing spontaneously"
- "Respiratory rate within normal parameters for age."
- "Patient is relaxed and breathing spontaneously."

Putney et al. (1994:1), Sena and Nathens (2010:8) and Mhanna et al. (2013:n.p) agree that the mechanically ventilated patient is ready for extubation when he or she has spontaneous respiratory efforts. Similarly, Abdel-Aal et al. (2010:4), El-Bayoumi et al. (2011:3) and Sifain and Papadakos (2011:31) indicate that spontaneous respiration should be present in order to successfully extubate the mechanically ventilated patient. According to Vidotto et al. (2011:2), the weaning process may be initiated when the patient has an adequate respiratory drive with absence of apnoea or tachypnoea. In the paediatric patient, the age specific parameters should be taken into consideration (see Table 2.4 on the normal respiratory rate according to age).

4.3.3.2 Bilateral air entry

Quotes from the participants during the workshop included the following:

- "With auscultation, good air entry."
- "Adequate equal air entry bilaterally."
- "Clear lung sounds, no wheezing and creps [crepitations]."

Sena and Nathens (2010:8) indicate that, in order to assess the patient for readiness for extubation, there should be no upper airway obstruction or stridor present; if any of this is present it may indicate that the lungs should be auscultated for bilateral air entry. Kanchi (2005:33) states weaning criteria include a "clear chest". Although several sources in literature were consulted (see Table 4.8), the researcher could find no additional literature pertaining to bilateral air entry as part of the weaning and extubation criteria.

Table 4.8: Consulted resources on bilateral air entry

Sources	Consulted authors	
	Paediatric authors	Adult authors
Articles/books	• Gatiboni et al. (2011) • Singh et al. (2011) • Johnston et al. (2010) • Saharan, Lodha and Kabra (2010) • Stein and Karam (2006)	• De Groot et al. (2011) • Sifain and Papadakos (2011) • Skillings and Curtis (2011) • Ahmed et al. (2010) • Vidotto et al. (2011) • Hemant, Chacko and Singh (2006) • Lermitte and Garfield (2005)

Sources	Consulted authors	
	Paediatric authors	Adult authors
Policy / protocol		• Putney et al. (2011) • Robertson (2007) • Union hospital (n.d.:n.p.)
University library	Librarian consulted: Used Medline	Librarian consulted: Used Medline
Other sources consulted: Key words used: bilateral air entry as extubation criteria after (paediatric) heart surgery	Researcher: Pubmed and PDF articles	Researcher: Pubmed and PDF articles

4.3.3.3 Endotracheal secretions

Quotes from the participants who took part in the workshop as regards endotracheal secretions included:

- "The secretions less": [free from pneumonia and infections].
- "Minimal clear or no secretions"
- "Secretions minimal and clear"

One of the indications for extubation is that the patient must be able to effectively clear pulmonary secretions (Robertson, 2007:3; El-Boyoumi, et al., 2011:3; Skillings & Curtis, 2011:43; Maung & Kaplan, 2012:15). Epstein (2009:40) notes that extubation failure often results from the patient's inability to protect her or his own airway and manage respiratory secretions. Wendell and Kofke (2011:1) indicate that copious secretions are associated with unsatisfactory airway maintenance and extubation failure. Lermitte and Garfield (2005:1) and Sena and Nathens (2010:8) agree that, as part of the extubation criteria, the required endotracheal suctioning should be less often than 4 hourly with no excessive secretions. This concurs with Bauman and Hyzy's (2012:3) view that endotracheal suctioning is required less than 2 to 3 hourly in order to successfully extubate the mechanically ventilated patient.

4.3.3.4 Saturation

With regard to saturation, the following quotes emerged from the participants during the workshop:

- "No signs of cyanosis"
- "Sats [saturation] above 90%"
- "Arterial blood gas normal"

The participants concurred that the saturation should be above 90% in order to extubate the mechanically ventilated patient following cardiothoracic surgery. According to Schutz (2001:1), the normal saturation value is above 95% in a patient with normal haemoglobin levels. The reason, Schutz (2001:1) explains, is that oxygen saturation is an indicator of the percentage of Haemoglobin saturated with oxygen at the time of the measurement. A saturation level above 95% is needed in order to extubate the mechanically ventilated patient (Paarmann, et al., 2012:3; Union hospital, n.d.:n.p.). According to Epstein (2010:2), Sena and Nathens (2010:8), De Groot et al. (2011:3) and de Souza et al. (2013:2) oxygen saturation above 90% is sufficient.

4.3.3.5 No laboured breathing

Pertaining to laboured breathing as part of the weaning and extubation criteria, participants communicated the following during the workshop:

- "No laboured breathing"
- "No use of accessory muscle[s]"
- "Adequate respiratory drive"

Stawicki (2007:14) opines that signs of increased breathing include nasal flaring, paradoxical breathing movements, and the use of accessory respiratory muscles. Anderson et al. (1994:880) share that laboured breathing is abnormal respiration characterised by evidence of increased effort, including use of accessory muscles of respiration, stridor, grunting and nasal flaring.

Sena and Nathens (2010:8), Singh et al. (2011:86) and Skillings and Curtis (2011:44) confirm that to successfully extubate the mechanically ventilated patient, there should be an absence of accessory muscle use. According to De Groot et al. (2011:3), the patient him- or herself should be able to deliver the work of breathing in order to be extubated; this means that the patient must have adequate muscle strength to be extubated (Ahmed, et al., 2010:29). Vidotto et al. (2011:2) further state no tachypnoea should be present as this could indicate increased respiratory effort.

4.3.3.6 Partial pressure of oxygen in arterial blood

During the workshop, the participants mentioned that the arterial blood gas had to be normal and the partial pressure of oxygen in arterial blood (PaO_2) more than 70 mmHg. The following quotes are evident of this statement:

- “Arterial blood gas normal”
- “Normal PaO_2”
- “PaO_2 to be more than 70 mmHg”

Ahmed et al. (2010:29) maintain the mechanically ventilated patient may be extubated if presenting with satisfactory arterial blood gasses. The participants agreed that the PaO_2 should be more than 70 mmHg in order to extubate the mechanically ventilated paediatric patient following cardiothoracic surgery. The participants’’ decision is confirmed by Engelbrecht and Tintinger (2007:4).

Gatiboni et al. (2011:200) state adequate gas exchange is indicated by a PaO_2 that is higher than 60 mmHg. Vidotto et al. (2011:2), Ascano (n.d.:n.p.) and the Union hospital (n.d.:n.p.) confirm this statement. Sena and Nathens (2010:8) place the PaO_2 as higher than 75 mmHg. These statements are contradicted by Paarmann et al. (2012:3) who state the optimal PaO_2 for extubation of the mechanically ventilated patient is above 80 mmHg. In agreement, Geyer, Mogotlane and Young (2011:333) note that the normal PaO_2 levels are between 80-90 mmHg. The researcher concluded that a lot of controversy exists on the adequate PaO_2 levels of the mechanically ventilated patient.

4.3.3.7 Partial pressure of carbon dioxide in arterial blood

As part of evidence quotes from the participants regarding normal levels of partial pressure of carbon dioxide in arterial blood ($PaCO_2$) are given next.

- "Normal $PaCO_2$"
- "Arterial blood gas normal"
- "$PaCO_2$ between 35-40 mmHg"

Weaning criteria include satisfactory arterial blood gasses (Ahmed, et al., 2010:29). Agreement was reached by the study participants that the $PaCO_2$ should be between 35-40 mmHg in order to extubate the mechanically ventilated patient following cardiothoracic surgery.

Vidotto et al. (2011:2) state the $PaCO_2$ should be between 30-40 mmHg when weaning the patient from mechanical ventilation while Ascano (n.d.:n.p.) mention the $PaCO_2$ should be less than 45 mmHg. It is the stance of Paarmann et al. (2012:3) that to extubate the mechanically ventilated patient, the $PaCO_2$ should be between 35-45 mmHg. Putney et al. (2011:1) ascertain the $PaCO_2$ should be "within the patient's normal limits".

4.3.3.8 Lactate

Quotes from the study participants to support this statement are as follows:

- "Blood gas normal"
- "Lactate less than 2 mmol/dL"
- "Normal lactic acid"

Saleh and Barr (2005:174) and Elbadri, Angela, Alshaari and Sheriff (2013:129) explain lactate is a marker of anaerobic metabolism, and elevated serum lactate levels have been correlated with rates of mortality. These authors further state that hyperlactataemia occurs above 2.2 mmol/dL (Saleh & Barr, 2005:178). Urden, Stacy and Lough (2002:927) explain anaerobic metabolism produces small amounts of energy but large amounts of lactic acid, and lactic academia causes more cellular damage. During times of stress and hypoperfusion, when aerobic metabolism may not meet tissue demands, anaerobic metabolism occurs (Slesinger 2011:115). Also, according to Slesinger (2011:115), a lactate above 4 mmol/dL is associated with a 28% mortality rate. Stated by Elbadri et al. (2013:129) normal lactate levels are 1-2 mmol/L. During the workshop, the participants agreed that the lactate should be less than 2 mmol/dL.

4.3.3.9 Potential hydrogen

During the workshop potential hydrogen (pH) was mentioned, but not consented upon. The researcher included some of the quotes from the participants:

- “Normal pH”
- “Normal metabolic status”
- “pH 7.35-7.45”

According to Marieb (2004:1048), all functional proteins such as haemoglobin are influenced by hydrogen (H) concentration; thus all biochemical reactions are influenced by the pH of their fluid environment. Both Marieb (2004:1048) and Geyer, Mogotlane and Young (2011:333) recognise that the normal pH levels are between 7.35-7.45. In the view of Paarmann et al. (2012:3) and de Souza et al. (2013:2) the optimal pH should be above 7.3. Ascano (n.d.:n.p.) states the pH should be more than 7.35 in order to extubate the mechanically ventilated patient. However, in contrast Putney et al. (2011:1) opine that only a pH of more than 7.30 should be considered when extubation of the mechanically ventilated patient is contemplated. Hemant, Chacko and Singh (2006:435) and De Groot et al. (2011:3) are of the opinion that in order to extubate the mechanically ventilated patient, the pH should be above 7.25. Concurring with the previous authors, Singh et al. (2011:85) also add that extubation failure occurs when the arterial blood pH is less than 7.25, thereby indicating that the pH should be higher than 7.25 to contribute to successful extubation.

Kanchi (2005:33) and Hemant, Chacko and Singh (2006:435) agree that weaning criteria include the absence of respiratory acidosis. This statement is confirmed by Robertson (2007:3), stating that acidosis increases the work of breathing.

In Table 4.9 a summary is given of the respiratory system, its sub-categories and the supportive authors.

Table 4.9: Assessment: Respiratory system

Category	Sub-category	Supportive authors	
		Paediatric authors	Adult authors
Respiratory system	**Spontaneous breathing**	• El-Bayoumi et al. (2011:3) • Mhanna et al (2013:n.p).	• Putney et al. (2011:1) • Sifain and Papadakos (2011:31) • Abdel-Aal (2010:4) • Sena and Nathens (2010:8) • Vidotto et al. (2011:2)
	Bilateral air entry	• Kanchi (2005:33)	• Sena and Nathens (2010:8)
	No excessive secretions	• El-Bayoumi et al. (2011:3)	• Lermitte and Garfield (2005:1) • Epstein (2009:40) • Sena and Nathens (2010:8) • Skillings and Curtis (2011:43) • Wendell and Kofke (2011:1) • Maung and Kaplan (2012:15)

Category	**Sub-category**	**Supportive authors**	
		Paediatric authors	**Adult authors**
	Saturation more than 90%		• Epstein (2010:2) • Sena and Nathens (2010:8) • De Groot et al. (2011:3) • De Souza et al. (2013:2)
	No signs of laboured breathing	• Singh et al. (2011:86)	• Sena and Nathens (2010:8) • Vidotto et al. (2011:2) • De Groot et al. (2011:3) • Skillings and Curtis (2011:44)
	PaO_2 more than 70 mmHg		• Engelbrecht and Tingtinger (2007:4) • Ahmed et al. (2010:29) • Paarmann et al. (2012:3)
	$PaCO_2$ between 35-40 mmHg		• Vidotto et al (2011:2)
	Lactate less than 2 mmol/dL	• Saleh and Barr (2005:174,178)	• Urden, Stacy and Lough (2002:927) • Ahmed et al. (2010:29) • Slesinger (2011:115) • Elbadri et al. (2013:129)
	pH 7.35-7.45		• Marieb (2004:1048) • Geyer, Mogotlane and Young (2011:333) • De Souza et al. (2013:2)

- **Conclusion**

The researcher found several controversies on oxygen saturation, PaO_2, $PaCO_2$, lactate levels and pH values. It is the opinion of the researcher that these values and the importance thereof should be explored further. Very importantly, the weaning and extubation criteria include spontaneous breathing, no laboured breathing and minimal endotracheal secretions, as confirmed by literature. Very little literature was found on bilateral air entry as part of the weaning and extubation criteria and should be explored further.

4.3.4 Renal system

The renal system is responsible for the maintenance of homeostasis in the body and for the excretion of waste products (Potts & Mandleco, 2007:623). According to Martin (2010:763), the urinary tract can be defined as “ducts and channels that conduct urine from the kidneys to the exterior”. Two sub-categories relating to the renal system emerged from the participants, namely urinary output of 0.5-1 ml/kg/hr and no abnormalities on urine dipstick testing. These sub-categories will be discussed in detail in Sections 4.3.4.1-4.3.4.2.

4.3.4.1 Urinary output

Quotes from the participants during the workshop concerning urinary output included:

- “Urinary output adequate”
- “Passing adequate volumes of urine”
- “Urinary output 0.5-1 ml/kg/hr”

The kidneys are highly vascular structures with a large endothelial surface area; consequently the inflammatory cascade related to bypass surgery adversely affects renal function (Ng & Goldman, 2007:1063). Accurate monitoring of hourly urinary output provides an indication of renal function (Monahan, et al., 2007:850). (Refer to Section 4.3.2.1 for haemodynamic stability and urinary output).

During the workshop, the participants concluded that urinary output should be 0.5-1 ml/kg/hr as part of the weaning and extubation criteria. This decision is confirmed by Bersten and Soni (2009:1119) who state a minimal acceptable urinary output is regarded as 0.5-1 ml/kg/hr and Paarmann et al. (2012:3) who advise urinary output should be above 1 ml/kg/hr. Hourly urinary output should be 1-2 ml/kg/hr according to Sadowski (2010:576). Kanchi (2005:33) and Sifain and Papadakos (2011:31) concur only 0.5 ml/kg/hr of urinary output is needed in order to consider extubation of the mechanically ventilated patient. According to Black and Hawks (2005:1894) and Karthekeyan et al. (2010:2), satisfactory urinary output is to be considered as part of weaning and extubation criteria in the cardiothoracic patient.

4.3.4.2 Urine dipstick

During the workshop the individual participants did not mention normal urinary dipstick, but it was mentioned and consented upon later in the workshop. It unanimously agreed, as evident in the quote below, that it has to be normal.

- “Normal dipstick”

The researcher could not find any literature relating to urine dipstick testing and weaning from mechanical ventilation, but Monahan et al. (2007:850) is of the opinion that the urine colour, pH and specific gravity provide important information about renal function. Byerley and Steiner (2011:855) discuss urinary tract infections in infants and children and the importance of urine dipstick testing, but no reference is made to connect it to extubation of the mechanically ventilated patient. The research literature consulted by the researcher in an attempt to find literature pertaining to urine dipstick and weaning from mechanical ventilation is summarised in Table 4.10.

Table 4.10 Consulted resources on urine dipstick

Sources	Consulted authors	
	Paediatric authors	**Adult Authors**
Articles/books	• Kanchi (2005) • Gatiboni et al. (2011) • Johnston et al. (2010) • Saharan, Lodha and Kabra (2010)	• Smeltzer and Bare (1996) • Marieb (2004) • Lermitte and Garfield (2005) • Hemant et al. (2006) • De Groot et al. (2011) • Sifain and Papadakos (2011)
Protocol/policy		• Putney et al. (2011)
University library	Librarian consulted: Used Medline	Librarian consulted: Used Medline
Other resources consulted: key words used: urine dipstick testing as extubation criteria after (paediatric) heart surgery	Researcher: Pubmed and PDF articles	Researcher: Pubmed and PDF articles

In Table 4.11 a summary of the renal system, including its sub-categories and supportive authors, are given.

Table 4.11: Assessment: Renal system

Category	Sub-category	Supportive authors	
		Paediatric authors	**Adult authors**
Renal system	**Urinary output 0.5-1 ml/kg/hr**	• Kanchi (2005:33) • Bersten and Soni (2009:1119)	• Sifain and Papdakos (2011:31)
	No abnormalities during urine dipstick testing		• Monahan et al. (2007:850) • Byerley and Steiner (2011:855)

- ## Conclusion

The researcher found minimal literature on the normal urinary output, normal urine dipstick testing and its relation to weaning and extubation criteria. It is the opinion of the researcher that these aspects should be explored further.

4.3.5 Gastrointestinal system

Potts and Mandleco (2007:661) state the primary function of the gastrointestinal system is ingestion, digestion, absorption of nutrients and elimination of waste products. According to Martin (2010:297), the term gastric relates to the stomach. Four sub-categories were named under the gastrointestinal system by the participants, namely absence of abdominal distention, absorption of all feeds, normal bowel sounds and blood glucose levels between 3.5 and 5.5 mmol/L. In Sections 4.3.5.1-4.3.5.4 these sub-categories will be discussed in detail.

4.3.5.1 No abdominal distention

Relevant quotes from the study participants during the workshop included:

- "Abdomen soft, not distended"
- "No abdominal distention"
- "Abdomen not distended"

Lermitte and Garfield (2005:2) state no abdominal distention should be present when weaning the patient from mechanical ventilation. Elzein (2009:153) is of the opinion that paediatric patients have limited respiratory reserve: they are disadvantaged by a increased chest wall compliance and rely on the diaphragm as the main muscle of respiration.

According to Keszler (2006:241), increased intra-abdominal pressure results in upward pressure on the diaphragm and decreases compliance of the respiratory system. Also stated by Porhomayon, Jahan, Papadakos, Panagiotis, Singh and Nader (2011:109) is that there is a decrease in lung compliance when there is excessive fat in and around the ribs, the diaphragm and the abdomen. These statements indicate that any form of abdominal distention will compromise the respiratory efforts in the mechanically ventilated patient; therefore, it should be taken into consideration when the patient is evaluated for weaning and extubation from mechanical ventilation. In fact, the aforementioned two articles are considered by the researcher as valuable evidence and are therefore mentioned in Table 4.14 as part of the literature control.

4.3.5.2 Absorption of feeds

Quotes from the participants with regard to the absorption of feeds are as follows:

- "Retaining feeds"
- "Absorbing feeds well"
- "Nutritional status good"

It is stated by Faisy, Lerolle, Dachraoui, Savard, Abboud, Tadie and Fagon (2009:1079) that nutritional support is based on the assumption that critically ill patients are prone to develop malnutrition. According to Sena and Nathens (2010:10), attention should be given to providing appropriate nutritional support to the mechanically ventilated patient in order to successfully wean and extubate. The respiratory muscles become weak after a few days of mechanical ventilation and may be catabolised for energy; thus, success in weaning requires early and aggressive nutritional support (Smeltzer, et al., 2010:663). Ingenito (2008:1687) advises that nutritional support should be maintained in all intubated patients whenever possible.

Lermitte and Garfield (2005:2) are of the opinion that the bowels should be functioning when weaning the patient from mechanical ventilation. According to Ingenito (2008:1687), delayed gastric emptying is common in critically ill patients who are usually on sedative medications. The researcher could not find much literature pertaining to absorption of feeds and weaning from mechanical ventilation. The researcher consulted more sources in order to find more confirmation. These sources are mentioned in Table 4.12.

Table 4.12 Consulted resources on absorption of feeds

sources	Consulted authors	
	Paediatric authors	**Adult Authors**
Articles/books	• Kanchi (2005) • Stein and Karam (2006) • Johnston et al. (2010) • Saharan, Lodha and Kabra (2010) • Gatiboni et al. (2011)	• Marieb (2004) • Hemant, Chacko and Singh (2006) • Faisy et al. (2009) • Sena and Nathens (2010) • De Groot et al. (2011) • Sifain and Papadakos (2011) • Skillings and Curtis (2011)
Protocol/policy		• Robertson (2007) • Putney et al. (2011) • Union hospital (n.d.:n.p.)
University library	Librarian consulted: Used Medline	Librarian consulted: Used Medline
Other resources consulted: key words used: Absorption of feeds in the (paediatric) patient as part of extubation criteria after heart surgery	Researcher: Pubmed and PDF articles	Researcher: Pubmed and PDF articles

4.3.5.3 Bowel sounds

Quotes from the study participants during the workshop included:

- "Bowel sounds present"
- "Bowel sounds clear"
- "Bowel sounds"

The presence of bowel sounds could be related to the absorption of feeds, although no direct mention is made in the literature. Lermitte and Garfield (2005:2) note in order to wean and extubate the patient from mechanical ventilation, the bowel should be functioning. This article by Lermitte and Garfield (2005:2) was the only literature found by the researcher referring to the functioning of the gastrointestinal tract and weaning from mechanical ventilation. Further sources were consulted as illustrated in Table 4.13.

Table 4.13 Consulted resources on bowel sounds

Sources	Consulted authors	
	Paediatric authors	**Adult authors**
Articles/books	• Kanchi (2005) • Johnston et al. (2010) • Saharan, Lodha and Kabra (2010) • Gatiboni et al. (2011)	• Hemant, Chacko and Singh (2006) • Faisy et al. (2009) • Sena and Nathens (2010) • De Groot et al. (2011) • Sifain and Papadakos (2011)
Policy/protocol		• Robertson (2007) • Putney et al. (2011) • Union hospital (n.d.:n.p.)
University library	Librarian consulted: Used Medline	Librarian consulted: Used Medline
Other sources consulted: key words used: bowel sounds as extubation criteria after (paediatric) heart surgery	Researcher: Pubmed and PDF articles	Researcher: Pubmed and PDF articles

4.3.5.4 Blood glucose

In the workshop it was decided that blood glucose levels at 3.5–5.5 mmol/L was normal as the following quotes show:

- "Haemoglucose test normal"
- "Normal blood glucose"
- "Blood glucose 3.5-5.5 mmol/L"

Blood glucose is defined by Anderson et al. (1994:205) as a group of closely related substances, such as glucose, fructose and galactose, which are normal constituents of blood and are essential for cellular metabolism. During the workshop the participants concluded that the normal blood glucose levels are 3.5-5.5 mmol/L and that it is part of the weaning and extubation criteria in order to extubate the mechanically ventilated patient following cardiothoracic surgery.

Bersten and Soni (2009:1120) advise that hypoglycaemia in children should be avoided; Sadowski (2010:579) adds that hypoglyceamia causes decreased cardiac contractility. Hypoglycaemia is defined as serum glucose between 2.2-3.3 mmol/L (Raman & Davis, 2011:170).

It is the opinion of Antonelli, Azoulay, Bonten, Chastre, Citerio, Conti, De Backer, Gerlach, Hedenstierna, Joannidis, Macrae, Mancebo, Maggiore, Mebazaa, Preiser, Pugin, Wernerman and Zhang (2011:407) that organ dysfunction is significantly associated with hyperglycaemia. Poddar (2011:531) states hyperglycaemia stimulates a cascade of pro-inflammatory events and increases oxidative stress. According to Raman and Davis (2011:174), hyperglycaemia is a blood glucose level higher than 13.75 mmol/L.

Normal blood glucose values given by Bersten and Soni (2009:1197) are between 3.9 and 6.2 mmol/L. Barone (2006:2620) ascertains the normal blood glucose values for a child is 3.3-5.6 mmol/L. Poddar (2011:534) is of the opinion that a blood glucose between 6-8.2 mmol/L is optimal. As evidenced in literature, no consensus has to date been reached on normal blood glucose levels.

In Table 4.14 a summary is given on the gastrointestinal system, the sub-categories and supportive authors.

Table 4.14: Assessment: Gastrointestinal system

Category	Sub-category	Supportive authors	
		Paediatric authors	**Adult authors**
Gastrointestinal system	**No abdominal distention**	• Keszler (2006:241)	• Lermitte and Garfield (2005:2) • Porhomayon et al. (2011:109)

Category	Sub-category	Supportive authors	
		Paediatric authors	Adult authors
	Absorption of feeds		• Lermitte and Garfield (2005:2)
	Normal bowel sounds		• Lermitte and Garfield (2005:2)
	Blood glucose 3.5-5.5 mmol/L	• Barone (2006:2620)	• Bersten and Soni (2009:1120)

- **Conclusion**

Very little literature was found by the researcher on the gastrointestinal system as part of weaning and extubation criteria. All four sub-categories and their significance should be further explored. Furthermore, a lot of controversies were found on the normal blood glucose levels of the paediatric patient.

4.4 Ventilator settings

During the workshop the following four ventilator settings were identified by the participants when extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery is considered, CPAP mode of mechanical ventilation, pressure support should be equal or less than 8 cmH_2O, PEEP should be 5 cmH_2O and fracture of inspired oxygen (FiO_2) should be 0,4.

Several contradictions to the ventilator settings were found in the literature. These controversies are discussed in Sections 4.4.1 to 4.4.4.

4.4.1 Continuous positive airway pressure mode of mechanical ventilation

Quotes from the participants about the continuous positive airway pressure (CPAP) mode of mechanical ventilation included the following:

- "CPAP"
- "Weaning mode"
- "Mode: CPAP"

CPAP allows the patient to breathe spontaneously while applying positive pressure throughout the respiratory cycle to keep alveoli open and promote oxygenation (Smeltzer, et al., 2010:662). CPAP mode is advised as soon as the patient is haemodynamic stable, on minimal ventilatory support, and having spontaneous breathing (Union hospital, n.d.:n.p.). It is advised by Ghuman, Newth and Khemani (2011:6) that in order to extubate the patients, they should first be put on CPAP mode of ventilation where they have to utilise their own respiratory muscles to generate the flow of air into the lungs. Lermitte and Garfield (2005:2), Robertson (2007:3) and Gatiboni et al. (2011:200), confirm this statement by observing that before the mechanically ventilated patient is extubated he or she should be started on a spontaneous breathing trial (CPAP). (Refer to Section 2.3.3.4 for a discussion on CPAP).

4.4.2 Pressure support

Regarding the setting of pressure support, the participants made some of the following statements:

- "Pressure minimal"
- "Reduce inspiratory pressure"
- "Pressure support less than 8cmH2O"

The participants concluded that to extubate the mechanically ventilated patient following cardiothoracic surgery, the pressure support should be set to equal or less than 8cmH_2O. Vidotto et al. (2011:2) also suggest the pressure support should be weaned down to 8 cmH_2O or less; Robertson (2007:3) and the Union hospital (n.d.:n.p.) are in agreement with Vidotto et al. (2011:2) that the pressure support should be weaned to 8 cmH_2O. On the other hand, Lermitte and Garfield (2005:2), Antonelli et al. (2011:399) and Gatiboni et al. (2011:200) ascertain the pressure support to be 7 cmH_2O. Then again, El-Bayoumi et al. (2011:3) state the pressure support should be at 10 cmH_2O in order to extubate the mechanically ventilated patient.

4.4.3 Positive end expiratory pressure

Consensus was reached among the participants that the positive end expiratory pressure (PEEP) should be weaned to 5 cmH_2O to extubate the mechanically ventilated patient following cardiothoracic surgery. The following quotes confirm this statement:

- "PEEP 5 cmH_2O"
- "PEEP 5 and below"
- "PEEP physiological"

The weaning and extubation criteria of the Union hospital (n.d.:n.p.) stipulate that the PEEP should be weaned to 5-8 cmH_2O. Lermitte and Garfield (2005:2), Epstein (2010:2), Antonelli et al. (2011:399), Vidotto et al. (2011:2), Gonçalves et al. (2012:2), and Ascano (n.d.:n.p.) all indicate that the PEEP should be 5 cmH_2O. To Saharan, Lodha and Kabra (2010:1300) a PEEP of 4-5 cmH_2O is acceptable when extubation of the mechanically ventilated patient is considered. By comparison, Robertson (2007), Sena and Nathens (2010:8) and Nery et al. (2011:761) agree that the PEEP should only be less or equal to 8 cmH_2O while De Groot et al. (2011:3) is satisfied with a PEEP less than 6 cmH_2O. Even more contradiction is added by Gatiboni et al. (2011:200) who state that PEEP should be less than 7 cmH_2O. (Refer to Table 2.2 on physiological PEEP levels).

4.4.4 Fracture of inspired oxygen

A fracture of inspired oxygen (FiO_2) of 0,4 was identified by study participants as part of the weaning criteria to extubate the mechanically ventilated patient following cardiothoracic surgery. Evidence of this finding is indicated by the following quotes:

- "FiO_2 0,4"
- "FiO_2 low as possible to maintain oxygenation and tissue perfusion"
- "FiO_2 less than 0,4"

It was stated in most literature sources that FiO_2 should be weaned to 0,4 or less when considering to extubate the mechanically ventilated patient (Johnston, et al., 2010:329; Saharan, Lodha & Kabra, 2010:1300; Gatiboni, et al., 2011:20; Singh, et al., 2011:86; Vidotto, et al., 2011:2; Gonçalves, et al., 2012:2; Paarmann, et al., 2012:3; de Souza et al. 2013:2 & Ascano n.d.:n.p). A few, namely Ahmed et al. (2010:29), Sena and Nathens (2010:8), De Groot et al. (2011:3), and the Union hospital (n.d.:n.p.) opine that the FiO_2 should be less than 0,5. In Table 4.15 a summary is given on the proposed ventilation settings and the supportive authors.

Table 4.15: Assessment: Ventilator settings

Ventilator settings	Supportive authors	
	Paediatric authors	**Adult authors**
CPAP	• Gatiboni et al. (2011:2) • Ghuman et al. (2011:6)	• Lermitte and Garfield (2005:2) • Robertson (2007:3) • Karmarkar and Varshney (2008:218) • Union hospital (n.d.:n.p.)
Pressure support 8 cmH_2O		• Robertson (2007:3) • Vidotto et al. (2011:2) • Union hospital (n.d.:n.p.)
PEEP 5 cmH_2O	• Saharan, Lodha and Kabra (2010:1300) • Antonelli et al. (2011:399) • El-Bayoumi et al. (2011:3) • Ascano (n.d.:n.p.)	• Lermitte and Garfield (2005:2) • Karmarkar and Varshney (2008:218) • Gonçalves et al. (2012:2) • Epstein (2010:2) • Vidotto et al (2011:2)
FiO_2 0,4	• Ascano (n.d.:n.p.) • Gatiboni et al. (2011:2) • Singh et al. (2011:86) • Johnston et al. (2010:329) • Saharan, Lodha and Kabra (2010:1300)	• Vidotto et al. (2011:2) • Gonçalves et al. (2012:2) • Paarmann et al. (2012:3) • De Souza et al. (2013:2)

- **Conclusion**

The researcher found vast contradictions in literature pertaining to the ventilator settings (refer to Table 4.15) proposed in order to extubate the mechanically ventilated patient. It is the opinion of the researcher that each of these settings should be further explored.

4.5 THEME 2: PLANNING

Theme 2, the planning phase, was the second step in the process of extubating the mechanically ventilated patient. During the planning phase the plan of care includes the relevant outcomes and intervention (Barnes Bolander, 1994:110). According to Lilley et al. (1996:9), the planning phase includes the identification of goals and outcome criteria. Novieastari (n.d.:n.p.) posit that the planning phase is a category of nursing behaviour in which the patient-centered goals and the expected outcomes are established and nursing interventions are selected in order to achieve the goals and outcomes of care. It is further stated by Novieastari (n.d.:n.p.) that the planning phase includes a clinical pathway. In this section, the equipment needed to extubate the mechanically ventilated patient following cardiothoracic surgery are discussed. During the workshop the researcher asked the following question:

- "Which equipment will you get ready to extubate your paediatric patient?"

4.5.1 Equipment

As soon as the mechanically ventilated patient complies with the identified weaning criteria, the equipment needed to successfully extubate the patient must be identified and ready. The endotracheal tube has to be removed in a therapeutic environment in which the patient can be monitored and in which emergency equipment is immediately available (Wratney & Cheifetz 2007:81). According to York Clark (2009:50), it is critical that the appropriate equipment to extubate the mechanically ventilated patient is present. York Clark (2009:50) and Skillings and Curtis (2011:43) identify several types of equipment needed to extubate the mechanically ventilated patient (refer to Table 4.16). It is stated by Stein and Karam

(2006:2573) that all supplies for intubation should be ready in order to extubate the mechanically ventilated patient. The equipment identified by the participants during the workshop consisted of:

- suction equipment
- humidifier
- oxygen connect
- flow meter
- nebulizer with prescribed medication
- emergency trolley
- nasal cannulae
- pulse oximeter
- mechanical ventilator

The above mentioned equipment will be discussed in Secions 4.5.1.2-4.5.1.8. In Table 4.16 the researcher provides a summary of the different extubation equipment identified by the participants during the workshop, Skillings and Curtis (2011:43) and by York Clark (2009:50).

Table 4.16: Extubation equipment identified by different sources

Equipment identified	Participants	Skillings and Curtis (2011)	York Clark (2009)
Suction equipment	Yes	Yes	Yes
Bag valve mask	No	Yes	Yes
Oxygen connection/delivery system	yes	Yes	Yes
Humidifier	Yes	No	Yes
Pulse oximeter	No	No	Yes
Equipment to re-intubate patient	No	Yes	Yes
Emergency trolley	Yes	Yes	No
Mechanical ventilator	Yes	No	No
Nebulizer with prescribed medication	Yes	Yes	No
Nasal cannulae	Yes	No	No

The equipment that must be ready to re-intubate the patient includes the bag valve mask, emergency trolley and the mechanical ventilator. Next, the emergency trolley and the mechanical ventilator as identified by the participants are discussed. The researcher included information on the bag valve mask which was mentioned once by participants during the workshop. The pulse oximeter is part of the monitoring system in the PCCU and is automatically included in the discussion (refer to Section 4.6.3.3).

4.5.1.1 Suction equipment

The participants were knowledgeable about the fact that the suction equipment needed to be at hand during extubation of the mechanically ventilated patient as the following quotes confirm:

- "Suction and catheter"
- "Suction pack and catheter"
- "Suctioning equipment"

Urden, Stacy and Lough (2002:599) state during extubation the patient should be suctioned and for this the suctioning equipment is needed. York Clark (2009:50), Skillings and Curtis (2011:43) and Bauman and Hyzy (2012:5) also identify that the suction equipment is needed for extubating the mechanically ventilated patient. In confirmation, Castro, Cortopass, Sabbag, Torre-Bouscoulet, Kümpel, Porto and Ferreira (2012:3) emphasise that the suction equipment must be available to the post-extubated patient.

4.5.1.2 Humidifier

The following quoted answers from the participants reflect that they were aware that it was necessary that humidifiers, oxygen and oxygen masks were needed for extubation:

- "Humidifier"
- "Humidifier, oxygen and connection"
- "Humidified oxygen"

York Clark (2009:51) indicates that an oxygen face mask and humidifier are some of the recommended equipment needed when extubating the mechanically ventilated patient. Skillings and Curtis (2011:45) also mention that after extubation the patient should be given humidified oxygen to help minimise airway swelling.

4.5.1.3 Oxygen connection

In the participants' verbatim quotes given next they indicate the necessity of having all the oxygen connections ready when extubation of the paediatric patient occurs:

- "Oxygen point"
- "Oxygen"
- "Oxygen gauge with christmas tree"

Castro et al. (2012:3) and Urden, Stacy and Lough (2002:599) are in agreement that after extubation, oxygen should be delivered to the patient. This statement is supported by York Clark (2009:50) and Bauman and Hyzy (2012:5) while Skillings and Curtis (2011:43) add that an oxygen source and tubing are needed in order to extubate the mechanically ventilated patient.

4.5.1.4 Nebulizer with prescribed medication

Concerning nebulizers and prescribed medication, the participants stated that

- "Hudson mask and inhalations"
- "Nebs mask and dilution as prescribed"
- "Inhalation mask for in case patient has stridor post-extubation"

Martin (2010:488) explain "that a nebulizer is an instrument used for applying a liquid in the form of a fine spray". According to Skillings and Curtis (2011:43), that supplemental oxygen with aerosol is necessary equipment for extubation of the mechanically ventilated patient. The reason for using aerosol is given by Skillings and Curtis (2011:45) as that it promotes warmth and moisture in the airways and prevents oxygen desaturation. It is the opinion of Lermitte and Garfield (2005:1), Stein and Karam (2006:2574) and Singh et al. (2011:86) that epinephrine aerosol should be available if a concern exists that the patient will have stridor after extubation.

4.5.1.5 Emergency trolley

Relating to the emergency trolley, the participants identified the following during the workshop:

- "Intubation apparatus in case patient does not cope and need[s] re-intubation."
- "Blade and laryngoscope"
- "Ambubag [bag valve mask] and airway"

The equipment essential for extubation includes that the emergency trolley must be available (Skillings & Curtis 2011:43).

4.5.1.6 Nasal cannulae

- "Nasal canullae [cannulae]"
- "Nasal prongs"
- "Oxygen mask/nasal canullae [cannulae]"

Gatiboni et al. (2011:200) state after extubation the paediatric patient should receive oxygen through nasal cannulae. Although Urden, Stacy and Lough (2002:599), York Clark (2009:51) and Skillings and Curtis (2011:43) mention that supplemental oxygen should be given to the extubated patient, not any of these authors specify whether the oxygen should be given via face mask or nasal cannulae. Singh et al. (2011:86), however, suggest that the paediatric patient should be put under a head box with oxygen after extubation.

4.5.1.7 Mechanical ventilator

In this, the planning phase, the participants agreed during the workshop that the mechanical ventilator as part of the endotracheal intubation and extubation supplies was essential during the extubation of paediatric patients following cardiothoracic surgery. The following quotes from some of the participants confirm this statement.

- "Intubation apparatus"
- "ET tube [endotracheal tube], same size as the patient was intubated with"
- "CPAP driver"

According to Martin (2010:775), a ventilator is equipment that is mechanically operated to maintain a flow of air into and out of the lungs of a patient who is unable to breathe normally. It is the opinion of Skillings and Curtis (2011:43) that endotracheal intubation supplies are necessary equipment when extubating a patient; it can thus be concluded that a mechanical ventilator is part of the endotracheal intubation supplies.

4.5.1.8 Bag valve mask

Stein and Karam (2006:2573) posit that "every extubation is a planned re-intubation". These authors stress the fact that that all supplies for re-intubation must be available at the bedside. Authors confirming that a bag valve mask is essential equipment for possible re-intubation include York Clark (2009:50) and Skillings and Curtis (2011:43). In Table 4.17 a summary of the needed equipment and supportive authors are presented.

Table 4.17: Planning: Equipment

Equipment	**Supportive authors**	
	Paediatric authors	**Adult authors**
Suction equipment		• Urden, Stacy and Lough (2002:599) • York Clark (2009:50) • Skillings and Curtis (2011:43) • Bauman and Hyzy (2012:5) • Castro et al. (2012:3)

Equipment	Supportive authors	
	Paediatric authors	Adult authors
Humidifier		• York Clark (2009:51) • Skillings and Curtis (2011:45)
O_2 connection		• Urden, Stacy and Lough (2002:599) • York Clark (2009:50) • Skillings and Curtis (2011:43) • Bauman and Hyzy (2012:5) • Castro et al. (2012:3)
Nebulizer mask with prescribed medication	• Stein and Karam (2006:2574)	• Lermitte and Garfield (2005:1) • Skillings and Curtis (2011:43)
Emergency trolley		• Skillings and Curtis (2011:43)
Nasal cannulae	• Gatiboni et al (2011:2)	• Urden, Stacy and Lough (2002:599) • York Clark (2009:51) • Skillings and Curtis (2011:43)
Mechanical ventilator on standby		• Skillings and Curtis (2011:43)
Bag valve mask		• York Clark (2009:50) • Skillings and Curtis (2011:43)

- **Conclusion**

The researcher found that the appropriate equipment in order to extubate the mechanically ventilated patient should be available and ready. Several sources in literature were found that confirmed this finding.

4.6 THEME 3: IMPLEMENTATION

Extubation from mechanical ventilation and the development of a clinical pathway in order to accomplish it was the main focus of this study. As part of Theme 3, implementation is the action of extubating the mechanically ventilated patient. As stated by Barnes Bolander (1994:111), the implementation phase consists of the provision of nursing care. Novieastari (n.d.:n.p.) further explains that the implementation phase includes the organisation of resources such as the equipment and care delivery to the patient; it also includes the anticipation and prevention of complications.

Tobin (2011:571) advise that the discontinuation of mechanical ventilation involves three steps, namely, the measurement of weaning predictors, a trial of unassisted breathing (CPAP) and a trial of extubation. In other words, the measurement of weaning predictors is the assessment phase, a CPAP trial is the planning phase and the extubation trial is the implementation phase. Indeed, Tobin's (2011:571) three steps of discontinuation of mechanical ventilation could be related to the nursing process which was, in fact, the conceptual framework of this study.

A definition of extubation is given in Chapter 1 and Chapter 2 of this study (refer to Sections 1.6.6.2 and 2.3.7). According to Skillings and Curtis (2011:43), the purpose of extubation is to remove the artificial airway to allow the patient to breathe independently.

4.7 THEME 4: EVALUATION

Theme 4 consists of the evaluation of the successful extubation of the mechanically ventilated patient. Barnes Bolander (1994:112) defines the evaluation phase as an "ongoing process that occurs whenever there is contact with the patient". The evaluation phase measures the patient's response to nursing actions and the patient's progress towards the achievement of goals (Novieastari, n.d.:n.p.).

The extubated patient requires frequent clinical evaluation during the post-extubation period (Hageman, Slotarski, Casserlymm & Hawkins, 2003:104). The authors further state these evaluations include frequent observation of breathing patterns, auscultation of the chest, and monitoring of vital signs. During the workshop, the researcher asked the following question:

- "How will you as nursing practitioner evaluate the paediatric patient in order to assess if the extubation process was successful?"

The evaluation is done according to all five body systems, namely the neurological, cardiovascular, respiratory, renal and gastrointestinal systems. These systems are discussed in Section 4.6.1 to Section 4.6.5.

4.7.1 Neurological system

During the workshop, the criteria identified by the study participants were that the paediatric patient should be awake and responsive and comfortable. These criteria will be discussed in detail in Sections 4.7.1.1-4.7.1.2.

4.7.1.1 Awake and responsive

The next three verbatim quotes from the participants relate to how the paediatric patient must be monitored for signs of being awake and responsive.

- "Normal Glascow coma scale"
- "Alert"
- "Awake, open eyes spontaneously"

Patient monitoring after extubation include her or his neurological status. It must be reported immediately if there is a change in the level of consciousness (Skillings & Curtis, 2011:45). Also, Vianello, Andrea, Arcaro, Giovanna, Braccioni, Fausto, Gallan, Federico, Marchi, Chizio, Stefania, Zampieri, Davide, Pegoraro, Elana and Salvador, Vittorino (2011:5), Vidotto et al. (2011:2) and Castro et al. (2012:3) concur that if a decrease in the patient's mental status occur, she or he should be re-intubated. The researcher found no literature mentioning the Glasgow coma scale and post-extubation evaluation.

4.7.1.2 Comfortable

As evidence to the statement that the paediatric patients must be comfortable, the following verbatim quotes from the participants during the workshop apply:

- "Pain control is adequate"
- "No more restless"
- "No irritation"

Skillings and Curtis (2011:46) are of the opinion that after extubation, the patient should be assessed for pain and analgesia should be administered as prescribed; thus it can be concluded that the patient should be kept comfortable. In Table 4.18 a summary of the neurological system, its sub-categories and the supportive authors are given.

Table 4.18: Evaluation: Neurological system

Category	Sub-category	Supportive authors	
		Paediatric authors	Adult Authors
Neurological system	**Awake and responsive**		• Skillings and Curtis (2011:45) • Vianello et al. (2011:5) • Vidotto et al. (2011:2) • Castro et al. (2012:3)
	Comfortable		• Skillings and Curtis (2011:46)

- ## Conclusion

The researcher found that even after the extubation of the mechanically ventilated patient following cardiothoracic surgery, the neurological system should still be assessed and evaluated.

4.7.2 Cardiovascular system

Urden, Stacy and Lough (2002:599) and Skillings and Curtis (2011:45) agree that after extubation, the patient's vital signs should be monitored. Criteria that were consented upon during the workshop were that the patient should be haemodynamically stable. This statement is further elaborated on in Section 4.7.2.1.

4.7.2.1 Haemodynamically stable

Quotes from the workshop to support the statement that the paediatric patient must be haemodynamically stable before extubation are given next.

- "Normal haemodynamic parameters"
- "No dysrhythmia, no tachycardia or bradycardia"
- "Haemodynamically stable"

Skillings and Curtis (2011:45) confirm that changes in pulse rate and blood pressure should be reported immediately if they occur after extubation. Urden, Stacy and Lough (2002:599), Hageman et al. (2003:104) and Bauman and Hyzy (2012:5) also state after extubation the patient's vital signs must be monitored. In Table 4.19 the supportive authors on the cardiovascular system are summarised.

Table 4.19: Evaluation: Cardiovascular system

Category	Sub-category	Supportive authors	
		Paediatric authors	**Adult Authors**
Cardiovascular system	**Haemodynamic stable**	• Hageman et al. (2003:104)	• Urden, Stacy and Lough (2002:599) • Skillings and Curtis (2011:45) • Bauman and Hyzy (2012:5)

- ## Conclusion

After extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery, she or he should be evaluated for haemodynamic stability.

4.7.3 Respiratory system

According to York Clark (2009:51), three important steps have to be taken after extubation, namely, to apply supplemental oxygen as indicated, auscultate for stridor and bilateral breath sounds, and to monitor respirations and pulse oximetry (saturation). During the workshop, four criteria were identified under the respiratory system, namely normal chest X-ray, no laboured breathing, saturation above 90% and normal lung sounds on auscultation. These criteria will be discussed in detail in Sections 4.7.3.1-4.7.3.4.

4.7.3.1 Normal chest X-ray

To support this statement, quotes from the participants are given next.

- "Normal chest x-ray [X-ray]"
- "Control chest x-ray [X-ray]"
- "Chest x-ray [X-ray]: no consolidation"

The chest X-ray is the most commonly used diagnostic tool in respiratory conditions and can be used to detect alterations in lung pathology (Geyer, Mogotlane, & Young, 2011:334). According to Stein and Karam (2006:2573), a chest X-ray should be obtained to check for post-extubation atelectasis. Spitzer, Greenspan and Fox (2003:166) state a chest X-ray must be taken after extubation to evaluate possible atelectasis. No mention was made in literature or during the workshop on the time period in which the chest X-ray should be taken after extubation of the mechanically ventilated paediatric patient. Therefore, the PCCU protocol should be used.

4.7.3.2 No laboured breathing

Quotes from the study participants related to spontaneous, non-distressed breathing and not laboured breathing included:

- "Breathing spontaneously, not in distress"
- "Not using accessory muscles to breathe"
- "No use of accessory muscles, no flaring of nostrils"

Urden, Stacy and Lough (2002:599) and Skillings and Curtis (2011:45) advise that after extubation the patient should be monitored for possible respiratory distress. If increased signs of respiratory effort such as tachypnoea or the use of accessory muscles occur, the patient should be re-intubated (Vianello, et al., 2011:5; Vidotto, et al., 2011:3; Castro, et al., 2012:3).

4.7.3.3 Saturation

The participants commented on saturation after extubation by stating the following:

- "Normal saturation"
- "No cyanosis"
- "The saturation ranges within the acceptable limits"

A peripheral saturation of 90% or below should be reported immediately if it occurs after extubation (Skillings & Curtis, 2011:45). The patient should be considered for re-intubation if saturation decreases below 90% (Vidotto, et al., 2011:2). Extubation failure occurs when the saturation is less than 88% (Singh, et al., 2011:85). Criteria for re-intubation include saturation less than 85% (Vianello, et al., 2011:5). Evidently there is controversy on the appropriate saturation levels post-extubation in literature.

4.7.3.4 Normal lung sounds on auscultation

Verbatim quotes from the workshop participants included the following three:

- "Good bilateral air entry, no creps [crepitations]"
- "Good air entry"
- "Auscultate for wheezing/air entry"

It is further stated by Urden, Stacy and Lough (2002:599) that the post-extubated patient should be observed for signs of airway occlusion. It can be therefore concluded that the lungs should be auscultated for bilateral air entry. Hageman et al. (2003:104) indicate that auscultation of the chest is part of post-extubation evaluation.

Auscultation is useful in assessing the flow of air through the bronchial tree and in evaluating the presence of fluid or solid obstruction in the lung structures (Smeltzer & Bare, 1996:445). In Table 4.20 a summary of the respiratory system, its sub-categories and supportive authors are given.

Table 4.20: Evaluation: Respiratory system

Category	Sub-category	Supportive authors	
		Paediatric authors	Adult authors
Respiratory system	**Normal chest X-ray**	• Spitzer, Greenspan and Fox (2003:166) • Stein and Karam (2006:2573)	
	No laboured breathing		• Urden , Stacy and Lough (2002:599 • Skillings and Curtis (2011:45) • Vianello et al. (2011:5) • Vidotto et al (2011:3) • Castro et al. (2012:3)
	Saturation above 90%		• York Clark (2009:51) • Skillings and Curtis (2011:45) • Vidotto et al. (2011:2)
	Normal lung sounds on auscultation	• Hageman et al. (2003:104)	• Urden, Stacy and Lough (2002:599) • York Clark (2009:51)

- **Conclusion**

The researcher found that most literature available on post-extubation evaluation pertains to the respiratory system. Literature on saturation and the absence of laboured breathing was sufficient, but more research is needed on post-extubation chest X-rays and normal lung sounds on auscultation.

4.7.4 Renal system

Under the renal system the main aspect was mentioned during the workshop, namely a urine output of 0.5-1 ml/kg/hr, which will be discussed in detail in Section 4.7.4.1.

4.7.4.1 Urinary output

As indicated in quotes from the participants during the workshop attention was paid to the urinary output.

- "Passing adequate amount of urine"
- "Urine output 0.5-1 ml/kg/hr"
- "Passing urine well"

No literature was found by the researcher on the relevance of urinary output after extubation of the mechanically ventilated patient. The researcher consulted several sources in literature as shown in Table 4.21.

Table 4.21 Consulted resources on urinary output

Sources	Consulted authors	
	Paediatric Authors	Adult Authors
Articles/books	• Gatiboni et al. (2011) • Singh et al. (2011)	
Policy/protocol		• Robertson (2007) • Union hospital (n.d.:n.p.)
Other sources consulted	Researcher: Pubmed and PDF articles	Researcher:Pubmed and PDF articles

In Table 4.22 a summary of the renal system, the sub-categories and supportive authors are given.

Table 4.22: Evaluation: Renal system

Category	Sub-category	Supportive authors	
		Paediatric authors	Adult Authors
Renal system	**Urine output 0.5-1 ml/kg/hr**	No support in literature	No support in literature

- **Conclusion**

The researcher could find no literature on urinary output monitoring after the extubation of the mechanically ventilated patient. This aspect should be explored further.

4.7.5 Gastrointestinal system

During the workshop, the single criterion identified relating to the gastrointestinal system by the participants was normal bowel sounds on auscultation, which is discussed in Section 4.7.5.1.

4.7.5.1 Normal bowel sounds on auscultation

Quotes from the participants to confirm that one criterion was identified by them included the following three:

- "Good bowel sounds"
- "Pass stools well"
- "Abdomen soft, not vomiting"

The researcher found no literature pertaining to the gastrointestinal system and the post-extubated patient. The researcher consulted several sources of literature as indicated in Table 4.23.

Table 4.23 Consulted resources on bowel sounds

Sources	Consulted authors	
	Paediatric Authors	**Adult Authors**
Articles/books	• Gatiboni et al (2011); • Singh et al (2011);	
Protocol/policy		• Robertson (2007) • Union hospital (n.d.:n.p.)
Other sources consulted	Researcher: Pubmed and PDF articles	Researcher: Pubmed and PDF articles

In Table 4.24 a summary of the gastrointestinal system, the sub-category and supportive authors are given.

Table 4.24: Evaluation: Gastrointestinal system

Category	Sub-category	Supportive authors	
		Paediatric authors	**Adult authors**
Gastrointestinal system	**Normal bowel sounds on auscultation**	No support in literature	No support in literature

- **Conclusion**

The researcher could not find any literature related to the gastrointestinal system and the evaluation of the post-extubation patient. Hence, it is suggested by the researcher that this aspect should be further explored.

4.8 THEME 5: DOCUMENTATION

Documentation is the last theme in the nursing process and should be done throughout; thus, it was integrated from Theme 1 to Theme 4 in this study. It is stated in the Nursing Standard of the State of Connecticut, USA (Anonymous:Online) that process involves evidence of the use of the themes of the nursing process. The researcher developed a clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery, refer to Annexure C1 and Annexure C2.

4.9 PHASE 3: REFINEMENT PHASE

4.9.1 Refinement of the clinical pathway:

The researcher developed a draft clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery during Phase 1 of this study (refer to Sections 3.3.1 to 3.3.4. During Phase 2 of this study, the researcher did a literature control (refer to Chapter 2). Phase 3 of this study consists of refinement of the draft clinical pathway (refer to Sections 3.3.5 to 3.3.7). The draft clinical pathway was handed back to each participant from Phase 1. The researcher requested of the participants to make alterations on the draft clinical pathway in writing. No alterations were made. During Phase 3 the researcher also made use of experts.

4.9.1.1 Population

The population included members of the multidisciplinary team, refer to Section 3.3.1 for clarification on population.

4.9.1.2 Sample

By use of purposive sampling, the researcher sampled four experts whom consented to participate in this study, refer to Section 3.3.7. The four experts included one anaethetist, one anaethetist/intensivist and two paediatricians.

4.9.1.3 Data collection

The researcher handed each expert the draft clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery and requested each expert to make alterations in writing on the draft clinical pathway. No alterations were made, but one expert included two articles with additional information which were utilized in the refinement of the final clinical pathway (refer to Table 3.3).

4.10 CONCLUSION

In Chapter 4 the researcher discussed the relevant weaning and extubation criteria needed in order to successfully extubate the mechanically ventilated paediatric patient following cardiothoracic surgery. In Chapter 5 the researcher discusses the conclusions and recommendations of this study.

5 CONCLUSIONS AND RECOMMENDATIONS

"I am still learning"

-Michelangelo (1475-1564)-

5.1 INTRODUCTION

In Chapter 4 the research findings and the relevant literature were discussed. A final clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery in a private hospital in Gauteng was developed. In Chapter 5, the conclusions and recommendations are given, including a personal reflection from the researcher.

Already discussed in Chapter 1, the scope of this research study included the paediatric patient in the PCCU who required cardiothoracic surgery and was mechanically ventilated post-operatively. The scope of this study did not only include the cardiothoracic paediatric patients who were mechanically ventilated, but also the criteria for the extubation of these patients.

Several limitations identified by the researcher had to be taken into consideration during the execution of this study. Firstly, the study was conducted in Gauteng, one of the nine provinces of South Africa. Secondly, it was done in a private, level 3 hospital (refer to Section 1.8.1). Hence, the study was not necessarily applicable to the government sector or the rest of the country due to differences in structures, resources, protocols and regulations.

5.2 AIM AND OBJECTIVES

The aim of this study was to develop a clinical pathway for the extubation of a paediatric patient following cardiothoracic surgery in a private hospital in Gauteng. In order to achieve this aim the objectives were to:

- explore the components of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery
- compile a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery

5.3 OBJECTIVE 1: EXPLORE THE COMPONENTS OF THE CLINICAL PATHWAY

The researcher conducted a workshop with critical care registered nurses and one physiotherapist, thus collecting a diverse amount of information from several specialists. In accordance with the nursing process which was used as the conceptual framework of this study, the following five themes were implemented: assessment, planning, implementation, evaluation and documentation.

5.3.1 Conclusion

During this study the nursing process was used as the conceptual framework. The nursing process consists of the five themes (also known as steps) listed below.

- Assessment
- Planning
- Implementation
- Evaluation
- Documentation

The study participants reached consensus on these five themes as well as on the categories and sub-categories related to the research findings.

5.3.1.1 Systemic Assessment

Assessment is the first step to be taken when considering the mechanically ventilated paediatric patient for extubation. The paediatric patient is assessed according to all the body systems and needs to comply to all criteria before the planning phase is pursued.

- **The paediatric patient**

For the purpose of this study the paediatric patient was defined as a mechanically ventilated child who is between six weeks and 12 years old.

- **System orientated assessment**

The body systems include the neurological, cardiovascular, respiratory, renal and gastrointestinal systems. Assessment is a continuous process. The assessment of the **neurological system** includes the criteria set out next.

- *Awake and responsive*. In order to extubate the mechanically ventilated paediatric patient, he or she should be awake and responsive and be able to maintain his or her airway.
- *Pupils reactive to light.* The researcher could not find literature pertaining to pupil reaction as criteria for extubation.
- *Patient should be pain free*. If the paediatric patient is pain free, he or she should be calm and more cooperative and successful extubation can be established.
- *Cough and swallow reflex should be present*. These reflexes should be present for the paediatric patient to maintain his or her own airway and thus improve the probability of successful and safe extubation from mechanical ventilation.

The assessment is the **cardiovascular system** which includes the following criteria:

- *Haemodynamically stable according to age parameters*. The researcher found a sufficient amount of literature on the importance of haemodynamic stability as criteria for extubation of the mechanically ventilated paediatric patient.
- *Venous access.* Venous access was not stated as important or relevant criteria for extubation of the mechanically ventilated paediatric patient in literature found by the researcher.
- *Chest tube drainage less than 30-50ml/24hrs*. This statement was not confirmed in literature.
- *Hb more than 10 g/dL*. Optimal Hb levels are important criteria for extubation as it directly influences the oxygenation status of the paediatric patient.

The assessment of the **respiratory system** the participants reached consensus on eight criteria, namely:

- *Spontaneous breathing at rate normal for age.* In order to extubate the mechanically ventilated paediatric patient she or he should be able to breathe independently.
- *Bilateral air entry present on auscultation*. The researcher found limited literature describing bilateral air entry as part of weaning and extubation criteria, but could establish that it is relevant to successful extubation.
- *Not excessive secretions*. Endotracheal secretions should be minimal for the paediatric patient to maintain her or his own airway.

- *Saturation to be above 90%.* Although the researcher found a significant amount of controversy in literature on the appropriate saturation levels of the mechanically ventilated paediatric patient, the literature all confirm that saturation should be at least above 90%.
- *No signs of laboured breathing present*. If laboured breathing is present, extubation will not be successful as the paediatric patient could be in respiratory distress.
- *PaO_2 above 70 mmHg*: The researcher found a lot of contradictory literature on the appropriate PaO_2 levels.
- *$PaCO_2$ 35-40mmHg:* The researcher found a lot of controversy in literature on the correct $PaCO_2$ levels.
- *Lactate less than 2mmol/dL*: High lactate levels are an indication of anaerobic respiration and could be a sign that the paediatric patient is in respiratory distress and not ready for extubation from mechanical ventilation.

The researcher included pH as part of the assessment under the respiratory system since as it was mentioned several times in literature.

The assessment of the **renal system** concluded:

- *Urine output 0.5-1 ml/kg/hr*. The optimal urinary output was discussed in literature as part of the weaning and extubation criteria.
- *No abnormalities to be detected using urine dipstick testing*. The researcher could not find literature pertaining to urine dipstick testing as part of the criteria for weaning and extubation.

Lastly, the **gastrointestinal system** was assessed and the following criteria were identified by the participants:

- *No abdominal distention present.* Abdominal distention puts pressure on the diaphragm and lungs and thus inhibits optimal ventilation in the paediatric patient. It is therefore considered as important criteria for extubation of the mechanically ventilated paediatric patient.
- *Absorption of feeds.* Literature describes the importance of optimal nutritional status in the mechanically ventilated paediatric patient; thus the researcher could conclude that absorption of feeds is also part of weaning and extubation criteria.
- *Normal bowel sounds present on auscultation.* Normal bowel sounds were not mentioned in literature as part of weaning and extubation criteria, but may be related to the absorption of feeds.

- *Blood glucose 3.5-5.5mmol/L.*The researcher found a lot of controversy on the optimal blood glucose levels in the paediatric patient.

This assessment phase included the relevant, minimal **ventilatory settings**:

During the workshop several ventilator settings were identified by the participants, namely: the ventilation mode, PEEP, pressure support and FiO_2. These ventilator settings should be reached before the mechanically ventilated paediatric patient can be safely and successfully extubated.

- Mode: Continuous positive airway pressure (CPAP)
- Pressure support less than 8 cmH_2O
- Positive end expiratory pressure (PEEP): 5 cmH_2O
- Fracture of inspired oxygen (FiO_2): 0,4

5.3.1.2. Planning

The planning phase is the second phase to be undertaken when considering the mechanically ventilated paediatric patient for extubation. This phase entails the **equipment** needed in order to undertake the third phase which is the implementation phase. A variety of equipment that is needed to extubate the mechanically ventilated paediatric patient was identified:

- *Suction equipment*. The paediatric patient should be suctioned during the implementation phase.
- *Humidifier*. Humidified oxygen should be available and administered to the paediatric patient in order to loosen any endotracheal secretions and thus improve the maintenance of his or her airway.
- *O_2 Connection*. Post-extubation the paediatric patient should be administered oxygen.
- *Nebulizer mask with prescribed medication*. Post-extubation the paediatric patient is given a nebulizer in order to treat any possible stridor.
- *Emergency trolley*. This is considered as part of re-intubation equipment.
- *Nasal cannulae* .A nasal cannulae is mostly used to administer oxygen post-extubation.
- *Mechanical ventilator*. The mechanical ventilator is considered as part of the re-intubation equipment.

The researcher added a bag valve mask to the equipment as confirmed in literature.

5.3.1.3 Implementation

The implementation phase is the third phase to be undertaken. This phase involves the actual extubation of the mechanically ventilated paediatric patient following cardiovascular surgery. When deciding to extubate the mechanically ventilated paediatric patient following cardiothoracic surgery, it should be remembered that the entire process involves the multidisciplinary team. Extubation consists of the actual removal of the endotracheal tube after the patient has been weaned from full ventilatory support.

- **Multidisciplinary team approach**

In this study the multidisciplinary team consisted of the critical care registered nurses, physiotherapists and paediatricians. All of these specialities are involved in the optimal and holistic care of the mechanically ventilated paediatric patient following cardiothoracic surgery.

5.3.1.4 Evaluation

After the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery, the second last phase in this process is undertaken, namely the evaluation of the post-extubated paediatric patient. As in the assessment phase, a systems approach is undertaken.

- **Systems approach to evaluation**

The body systems include the **neurological**, **cardiovascular**, **respiratory**, **renal** and **gastrointestinal** systems. During the workshop the participants identified several criteria for the evaluation of the post-extubated paediatric patient.

The evaluation criteria included the **neurological system:**

- *Awake and responsive*. Literature confirms that if any deterioration on the paediatric patient's level of consciousness is observed, then the paediatric patient should be re-intubated.
- *Comfortable:* The paediatric patient should be pain free, comfortable and also cooperative in order to ventilate and oxygenate optimally.

The **cardiovascular system** included that the paediatric patient should be:

- *Haemodynamically stable according to age parameters.* If sudden instability occurs, the paediatric patient should be re-intubated.

The **respiratory system** criteria included:

- *Chest X-ray normal.* A post-extubation chest X-ray is performed in order to assess any consolidation.
- *No laboured breathing present*. Laboured breathing is a sign of respiratory distress and the paediatric patient should be re-intubated.
- *Saturation above 90%.* Literature confirms that saturation below 90% is an indication for the paediatric patient to be re-intubated.
- *Normal lung sounds on auscultation.* Normal lung sounds indicate optimal ventilation.

The **renal system** included only one mentioned aspect:

- *Urine output 0.5-1 ml/kg/hr.* The researcher could not find any literature on urinary output as part of the evaluation of the post-extubated paediatric patient.

The **gastrointestinal system**:

- *Normal bowel sounds on auscultation*. The researcher could not find any literature indicating the relevance of normal bowel sounds as part of the evaluation of the post-extubated paediatric patient.

5.3.1.5 Documentation

The last theme of the nursing process is the documentation phase. Every action the critical care registered nurse takes must be recorded; it is thus an integration of Theme 1 to Theme 4.

5.4 OBJECTIVE 2: COMPILE A CLINICAL PATHWAY

The second objective of this study was to compile a final clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery in a private hospital in Gauteng.

5.4.1 Conclusion

During the Phase 1 of this study the components of the clinical pathway to extubate the mechanically ventilated paediatric patient following cardiothoracic surgery were explored. The researcher facilitated a workshop and the participants reached consensus on several extubation criteria. From these criteria a draft clinical pathway was compiled and distributed to seven experts for evaluation.

Four of these experts gave feedback and were satisfied that the draft clinical pathway was relevant, systematic, user-friendly and useful. From there, the researcher compiled a final clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery.

It is stated in literature that no actual clinical pathway evaluation instrument exists and thus this clinical pathway can only be evaluated during the implementation thereof.

5.5 RECOMMENDATIONS

The researcher made recommendations related to this study. These recommendations include clinical practice, management, nursing education, and future research.

5.5.1 Clinical practice

Even though clinical pathways are utilised throughout the world, it is still a new and unfamiliar concept in South Africa. Clinical pathways are based on evidence-based practice, and are relevant and extremely useful in the dynamic field of medical and nursing science. The researcher therefore recommends that clinical pathways and their advantages should be further explored because it is cost-effective, ensures optimal and holistic patient care, and utilises the newest research available.

5.5.2 Management

Management includes quality improvement and family satisfaction. The advantages of clinical pathways are that the patient receives holistic and optimal quality care that is based on the most recent research and medical knowledge. Hospital management should be aware of the importance of the development and implementation of clinical pathways, as their support and approval are necessary in the development and implementation of a clinical pathway.

5.5.2.1 Quality improvement

Quality improvement in the hospital setting involves the continuous collaboration of the multidisciplinary team members and keeping the focus on evidence-based practice. The development and implementation of clinical pathways encourage quality improvement through involving all multidisciplinary team members in patient care, focusing on optimal and holistic patient care, shortening of hospital stay and thus cutting hospital costs, enhancing patient satisfaction and utilising evidence-based practice.

5.5.2.2 Barriers to developing a clinical pathway

The utilisation of clinical pathways has many advantages, but several barriers are encountered when developing clinical pathways. The following barriers should be taken into consideration when developing a clinical pathway:

- *Resources.* The availability of knowledgeable staff and other resources such as finances and time can make the development of clinical pathways very difficult.
- *Knowledge.* As clinical pathways are still a new concept in South Africa, the relevant knowledge and skill in developing clinical pathways may pose a barrier. Hospital management and hospital staff should be encouraged to learn about clinical pathways and their development.

5.5.3 Nursing education

Nursing education can change the mindset of nursing practitioners about clinical pathways and the benefits thereof. Education should include:

- The importance and significance of clinical pathways. Also, the development and implementation thereof.
- Relevance of evidence-based practice. The importance of being aware and knowledgeable about the most recent research and evidence-based practice are essential for optimal and holistic patient care.
- Multidisciplinary team approach. The involvement of the multidisciplinary team members encourages holistic patient care and the use of multiple and diverse knowledge and skills.

- Continuous personal development. The medical field is a very dynamic profession and the nursing practitioner should strive for continuous self- and professional development.

5.5.4 Future research

Future research should include aspects of assessment and evaluation on all five body systems related to the development of the clinical pathway for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery in a private hospital in Gauteng. These recommendations are based on the fact that limited literature is available on paediatrics and the extubation criteria of these vulnerable patients.

- **Assessment of the neurological system**

The researcher found a significant amount of literature pertaining to the fact that the mechanically ventilated patient has to be awake and responsive before extubation is considered. Much literature on pain control and the cough and swallow reflexes were found but very little on pupillary responses relating to extubation from mechanical ventilation.

It is the opinion of the researcher that further research is needed on the importance, or then possible insignificance, of pupillary responses and extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery, based on the fact that limited research is available on this topic.

- **Assessment of the cardiovascular system**

Haemodynamic stability is extremely important as part of weaning and extubation criteria as evidenced in literature. The optimal Hb levels are also indicated as important criteria when the paediatric patient is assessed for extubation readiness.

The researcher found very little literature pertaining to IV access and chest tubeage as part of weaning and extubation criteria and she is of the opinion that these aspects should be further explored.

- **Assessment of the respiratory system**

A lot of controversy was found in the literature concerning oxygen saturation, PaO_2,

$PaCO_2$, lactate and pH values. The researcher believes that these values and the importance thereof should be further researched. Criteria identified as very important under the respiratory system were spontaneous breathing, no presence of laboured breathing, and minimal endotracheal secretions. The researcher found literature on bilateral air entry as part of weaning and extubation criteria was scarce and is of the opinion that this aspect should be further explored.

- **Assessment of the renal system**

As mentioned in literature, a normal urinary output should be considered as part of weaning and extubation criteria, but minimal literature was found on normal urine dipstick testing and its relation to the extubation of the paediatric patient following cardiothoracic surgery. The researcher suggests that this aspect should be further researched.

- **Assessment of the gastrointestinal system**

As evidenced in this study findings, there is insufficient literature on the gastrointestinal system as part of weaning and extubation criteria. A lot of controversy was found by the researcher on normal blood glucose levels of the paediatric patient. These aspects should be further explored.

- **Ventilator settings**

Literature provides a vast amount of controversy on the relevant ventilatory settings for the extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery. These settings are important aspects to be further explored and evaluated.

- **Evaluation of the respiratory system**

In the evaluation phase, the researcher found that the majority of available literature describes the respiratory system, especially oxygen saturation and the absence of laboured breathing. The researcher is of the opinion that more research is needed on post-extubation chest X-rays and normal lung sounds on auscultation.

- **Evaluation of the renal system**

No literature on urinary output monitoring post-extubation of the mechanically ventilated paediatric patient following cardiothoracic surgery was found. The researcher proposes this to be topic for further research.

- **Evaluation of the gastrointestinal system**

No literature was found by the researcher pertaining to the gastrointestinal system and the evaluation of the paediatric patient post-extubation. It is suggested by the researcher that this aspect is further explored.

5.6 PERSONAL REFLECTION

As the researcher concerned with this study, I have learned and experienced a great deal. Initially I was extremely motivated and excited to conduct the study. It was a personal and professional challenge I wanted to, and did, accept. However, as I continued with the study, it became more and more difficult for me to stay focused and motivated. A study such as this one takes a lot of time, effort and hard work. But with personal reflection, self-motivation, and support from my family, friends and my supervisors, I was able to complete this study.

I have learned that without hard work and effort, very little can be accomplished in life. Conducting this study has contributed to my own personal as well as professional growth. (I have even learned a few computer skills.). As the study evolved and reached an end I became more and more aware that becoming receptive to new ideas, experiencing and overcoming unforeseen challenges, and receiving unconditional love and support from those you know as well as those who used to be strangers, one grows as a human being and as a professional. I have realised that one has to persevere and meet every challenge in life with enthusiasm, an open mind and a determined soul.

Finally, I would recommend to any registered nurse and medical professional to begin and complete a post-graduate study such as this to learn, develop and improve evidence-based practice in the healthcare profession.

5.7 SUMMARY OF THIS STUDY

The utilisation of clinical pathways is very new in South Africa and should still be further explored in the medical and nursing fields. The researcher focused on the development of a clinical pathway for the extubation of the paediatric patient following cardiothoracic surgery in a private hospital in Gauteng. Currently, limited literature is available on this topic, and especially in the field of paediatrics.

The nursing process was used as the conceptual framework and once again proved that all nursing procedures and actions are based on five themes, namely, assessment, planning, implementation, evaluation and documentation. The researcher made several suggestions for further research. A personal reflection from the researcher was included in this chapter.

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Annexure A

Ethical permission

Annexure A1

Ethical permission

University of Pretoria

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

28/07/2010

Number	:	**S137/2010**
Title	:	Developing a clinical pathway for the extubation of a mechanically ventilated paediatric patient in a private hospital in Gauteng
Investigator	:	Marinda du Plessis, Department of Nursing Science, University of Pretoria (SUPERVISORS: Dr IM Coetzee / Dr T Heyns)
Sponsor	:	**None**
Study Degree:		**M Cur Clinical**

This Student Protocol was approved by the Faculty of Health Sciences Research Ethics Committee, University of Pretoria on 27/07/2010. The approval is valid for a period of 3 years.

Prof M J Bester	BSc (Chemistry and Biochemistry); BSc (Hons)(Biochemistry); MSc(Biochemistry); PhD (Medical Biochemistry)
Prof R Delport	(female)BA et Scien, B Curationis (Hons) (Intensive care Nursing), M Sc (Physiology), PhD (Medicine), M Ed Computer Assisted Education
Prof V.O.L. Karusseit	MBChB; MFGP (SA); MMed (Chir); FCS (SA)
Prof J A Ker	MBChB; MMed(Int); MD – Vice-Dean (ex officio)
Dr M L Likibi	MBChB; Med.Adviser (Gauteng Dept.of Health)
Dr MP Mathebula	Deputy CEO: Steve Biko Academic Hospital
Prof T S Marcus	(Female) BSc (LSE), PhD (University of Lodz, Poland)
Prof A Nienaber	(Female) BA (Hons) (Wits); LLB (Pretoria); LLM (Pretoria); LLD (Pretoria); PhD; Diploma in Datametrics (UNISA)
Prof L M Ntlhe	MBChB(Natal); FCS(SA)
Mrs M C Nzeku	(Female) BSc(NUL); MSc Biochem(UCL,UK)
Snr Sr J. Phatoli	(Female) BCur (Et.Al); BTech Oncology
Dr R Reynders	MBChB (Pret), FCPaed (CMSA) MRCPCH (Lon) Cert Med. Onc (CMSA)
Dr T Rossouw	(Female) MBChB.(cum laude); M.Phil (Applied Ethics) (cum laude), MPH (Biostatistics and Epidemiology (cum laude), D.Phil
Mr Y Sikweyiya	MPH (Umea University Umea, Sweden); Master Level Fellowship (Research Ethics) (Pretoria and UKZN); Post Grad. Diploma in Health Promotion (Unitra); BSc in Health Promotion (Unitra)
Dr L Schoeman	(Female) BPharm (NWU); BAHons (Psychology)(UP); PhD (UKZN); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair** (Female) - MBChB; MMed (Int); MPharMed.
Prof T J P Swart	BChD, MSc (Odont), MChD (Oral Path), PGCHE
Prof G van Biljon	(female)FCP (Paed)SA
Prof C W van Staden	**Chairperson** - MBChB; MMed (Psych); MD; FCPsych; FTCL; UPLM; Dept of Psychiatry

Student Ethics Sub-Committee

Prof R S K Apatu	MBChB (Legon,UG); PhD (Cantab); PGDip International Research Ethics (UCT)
Dr A M Bergh	(female) BA (RAU); BA (Hons) (Linguistics) (Stell); BA (Hons) (German) (UNISA); BEd (Pretoria); PhD (Pretoria); SED (Stell)
Mrs N Briers	(female) BSc (Stell); BSc Hons (Pretoria); MSc (Pretoria); DHETP (Pretoria)
Dr S I Cronje	BA (Pretoria); BD (Pretoria); DD (Pretoria)
Prof M M Ehlers	(female) BSc (Agric) Microbiology (Pret); BSc (Agric) Hons Microbiology (Pret); MSc (Agric) Microbiology (Pret); PhD Microbiology (Pret); Post Doctoral Fellow (Pret)
Prof D Millard	(female) B.Iur (Pretoria); LLB (Pretoria); LLM (Pretoria); AIPSA Diploma in Insolvency Law (Pretoria); LLD (UJ)
Dr S A S Olorunju	BSc (Hons). Stats (Ahmadu Bello University –Nigeria); MSc (Applied Statistics (UKC United Kingdom); PhD (Ahmadu Bello University – Nigeria)
Dr L Schoeman	CHAIRPERSON: (female) BPharm (North West); BAHons (Psychology)(Pretoria); PhD (KwaZulu-Natal); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair** (Female) MBChB; M.Med (Int); MPhar.Med

DR L SCHOEMAN; BPharm, BA Hons (Psy), PhD;
Dip. International Research Ethics
CHAIRPERSON of the Faculty of Health Sciences
Student Research Ethics Committee, University of Pretoria

DR R SOMMERS; MBChB; M.Med (Int); MPhar.Med.
VICE-CHAIR of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

012 354 1677 0866516047 deepeka.behari@up.ac.za http://www.healthethics-up.co.za
P O Box 667, Pretoria, 0001 31 Bophelo Road, HW Snyman South Building, Level 2, Room 2.33, Gezina, Pretoria

Annexure A2

Ethical permission of the hospital

Dear Marinda du Plessis

LETTER OF PROVISIONAL PERMISSION TO CONDUCT RESEARCH IN A [redacted] FACILITY

It is with pleasure that we inform you that your application to conduct research on **CONSTRUCTING A CLINICAL PATHWAY FOR THE EXTUBATION OF THE CARDIOTHORACIC PAEDIATRIC PATIENTS** at [redacted] has been approved in principle, subject to the following:

i) Approval by the Research Committee
ii) All information with regards to [redacted] will be treated as confidential.
iii) [redacted] name will not be mentioned without written consent from the Academic Board of [redacted]
iv) Where [redacted] name is mentioned, the research will not be published without written consent from the Academic Board of [redacted]
v) A copy of the research will be provided to [redacted] once it is finally approved by the tertiary institution, or once complete.
vi) All legal requirements with regards to patient rights and confidentiality will be complied with.

We wish you success in your research.

Yours faithfully

Adélle Johnstone
Hospital Manager

Nicolet Bronner
Nursing Manager

Annexure B

Participant's information

Annexure B1

Informed consent

Participation information leaflet and informed consent
ICU registered nurses and physiotherapists

Dear colleague

1. Title of the study

Develop a clinical pathway for the extubation of the paediatric patient in a private hospital in Gauteng.

Thank you for your consent to participate in the workshop regarding the abovementioned topic. The total time scheduled for the workshop is four hours, starting at 08h30. Date: 12 September 2011. Venue: University of Pretoria, Medical campus, 8th floor, room 8-1.

2. The aim of the study

You are requested to participate in a research study. The aim of this study is to gather information for the development of a clinical pathway for the extubation of the mechanically ventilated paediatric patient, following cardiothoracic surgery. Using the gathered information, a clinical pathway will be developed.

3. Explanation of procedures to be followed

You are asked as an ICU registered nurse or physiotherapist who specializes in mechanical ventilation to participate in this study. Your participation will be as an individual, not representing the institution you work for. During the workshop you will be divided into a group. The researcher will facilitate the workshop. You will be handed a paper and a pen, and asked to answer some questions in writing.

4. Risks involved

Participating in this study will take approximately four hours of your time, further you will experience no discomfort.

5. Benefits of the study

As participant you will have the satisfaction that your contribution of information could make a vast difference in future nursing and medical care.

6. Voluntary participation in and withdrawal from the study

Your participation in the study is completely voluntary and you will not be penalized for not participating. You are allowed to withdraw at any time, without stating any reason. There will also be no penalty for withdrawal from the study.

7. Ethical approval

The Faculty of Health Sciences Research Ethics Committee at the University of Pretoria has granted written approval for this study.

8. Additional information

It you have any queries about the study and/or your participation in the study, you may contact the researcher, Mrs Marinda du Plessis.

Cell phone: 083 37 000 76

Email address: duplessis.marinda@gmail.com

9. Consent to participate in this study

Your participation is subject to reading, understanding and accepting the above information and signing the informed consent document.

INFORMED CONSENT

I have read the information leaflet above and I fully understand what is expected of me. I understand that consent to this study is completely voluntary and that I may withdraw at any time. I have been given the opportunity to ask questions. I hereby volunteer to take part in the research study.

___________________________________ ____________________

Participant's signature **Date**

___________________________________ ____________________

Researcher's signature **Date**

___________________________________ ____________________

Witness signature **Date**

Participation information leaflet and informed consent
Paediatricians and pulmonologists

Dear Doctor

1. Title of the study

Develop a clinical pathway for the extubation of the paediatric patient in a private hospital in Gauteng.

2. The aim of the study

You are requested to participate in a research study. The aim of this study is to gather information for the development of a clinical pathway for the extubation of the paediatric patient, following cardiothoracic surgery. A draft of the clinical pathway will already be set up.

3. Explanation of procedures to be followed

You are asked as a paediatrician and/or pulmonologist who specialize in mechanical ventilation to participate in this study. Your participation will be as an individual, not representing the institution you work for.

You are asked to validate the draft clinical pathway. Please assess the pathway, and feel free to make any changes directly on the document. If any changes are made, please attach the relevant literature and references to the document. The document with all the references should then be handed back to the researcher, within five working days.

4. Risks involved

Participating in this study will take some of your time and effort, further you will experience no discomfort.

5. Benefits of the study

As participant you will have the satisfaction that your contribution of information could make a vast difference in future nursing and medical care.

6. Voluntary participation in and withdrawal from the study

Your participation in the study is completely voluntary and you will not be penalized for not participating. You are allowed to withdraw at any time, without stating any reason. There will also be no penalty for withdrawal from the study.

7. Ethical approval

The Faculty of Health Sciences Research Ethics Committee at the University of Pretoria has granted written approval for this study.

8. Additional information

It you have any queries about the study and/or your participation in the study, you may contact the researcher, Mrs Marinda du Plessis.

Cell phone: 083 37 000 76
Email address: duplessis.marinda@gmail.com

9. Consent to participate in this study

Your participation is subject to reading, understanding and accepting the above information and signing the informed consent document.

INFORMED CONSENT

I have read the information leaflet above and I fully understand what is expected of me. I understand that consent to this study is completely voluntary and that I may withdraw at any time. I have been given the opportunity to ask questions. I hereby volunteer to take part in the research study.

__________________________________ ____________________

Participant's signature **Date**

__________________________________ ____________________

Researcher's name **Date**

__________________________________ ____________________

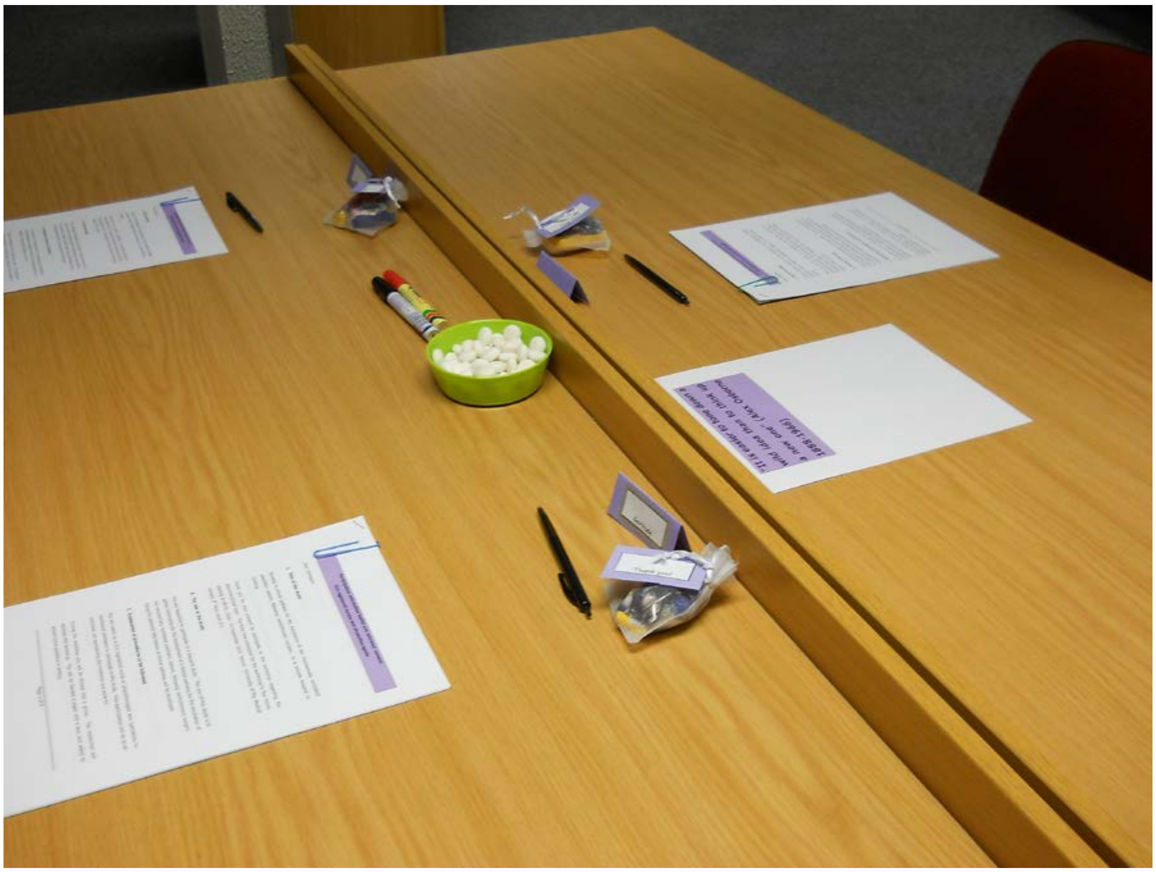
Witness signature **Date**

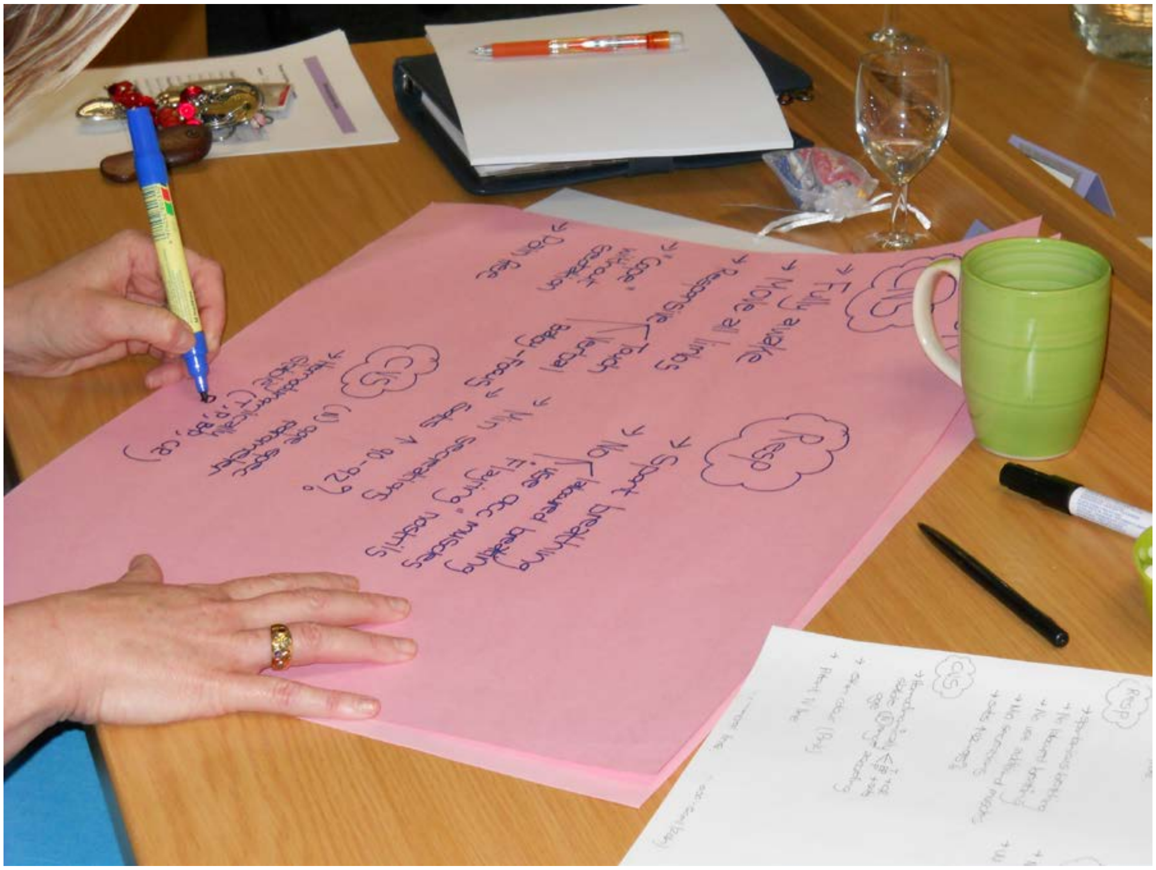
Annexure B2

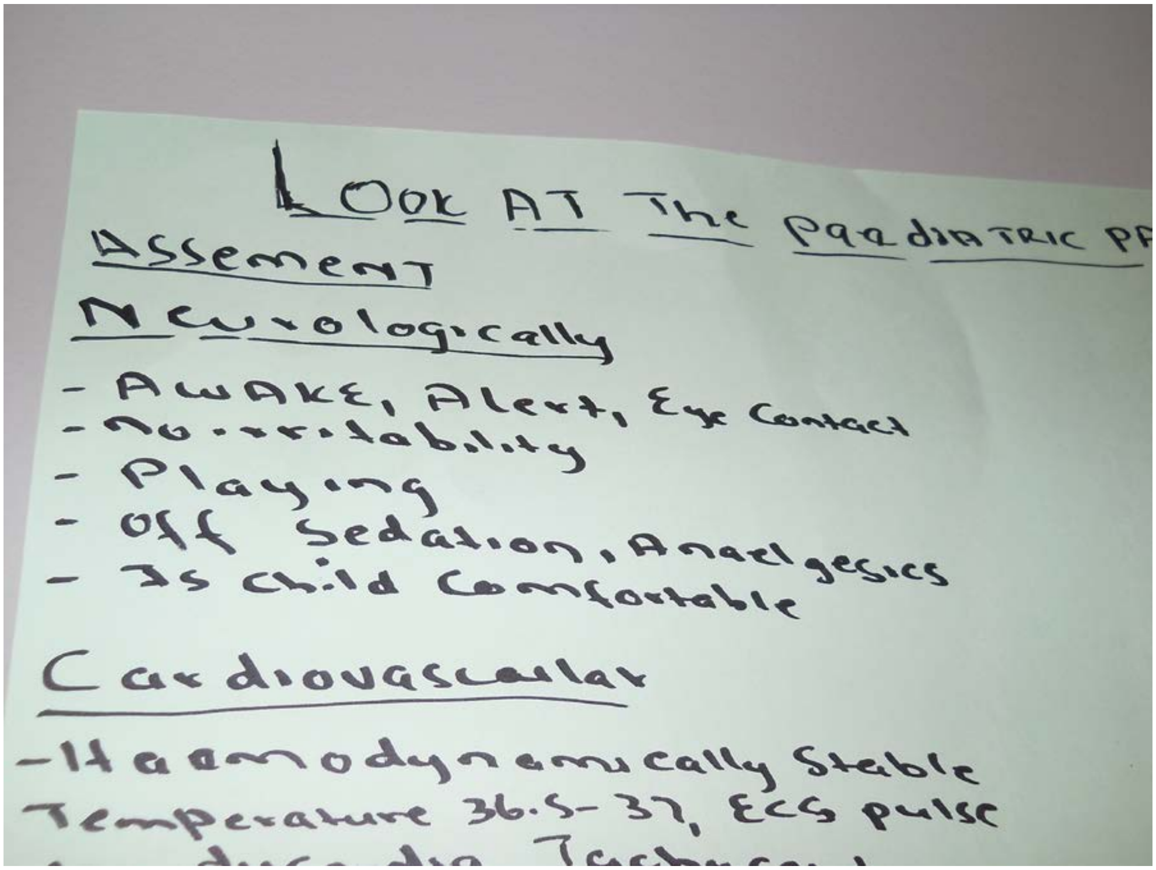
Participant's inputs

and

evidence of workshop




Fully awake
Move all limbs
Resp
Spont breathing


LOOK AT The Paadiatric
Assement
Neurologically
- AWAKE, Alert, Eye Contact
- no irritability
- Playing
- off Sedation, Anaelgesics
- Is child Comfortable
Cardiovascular
- Haemodynamically Stable
Temperature 36.5-37, ECG pulse

Annexure B3

Program of workshop

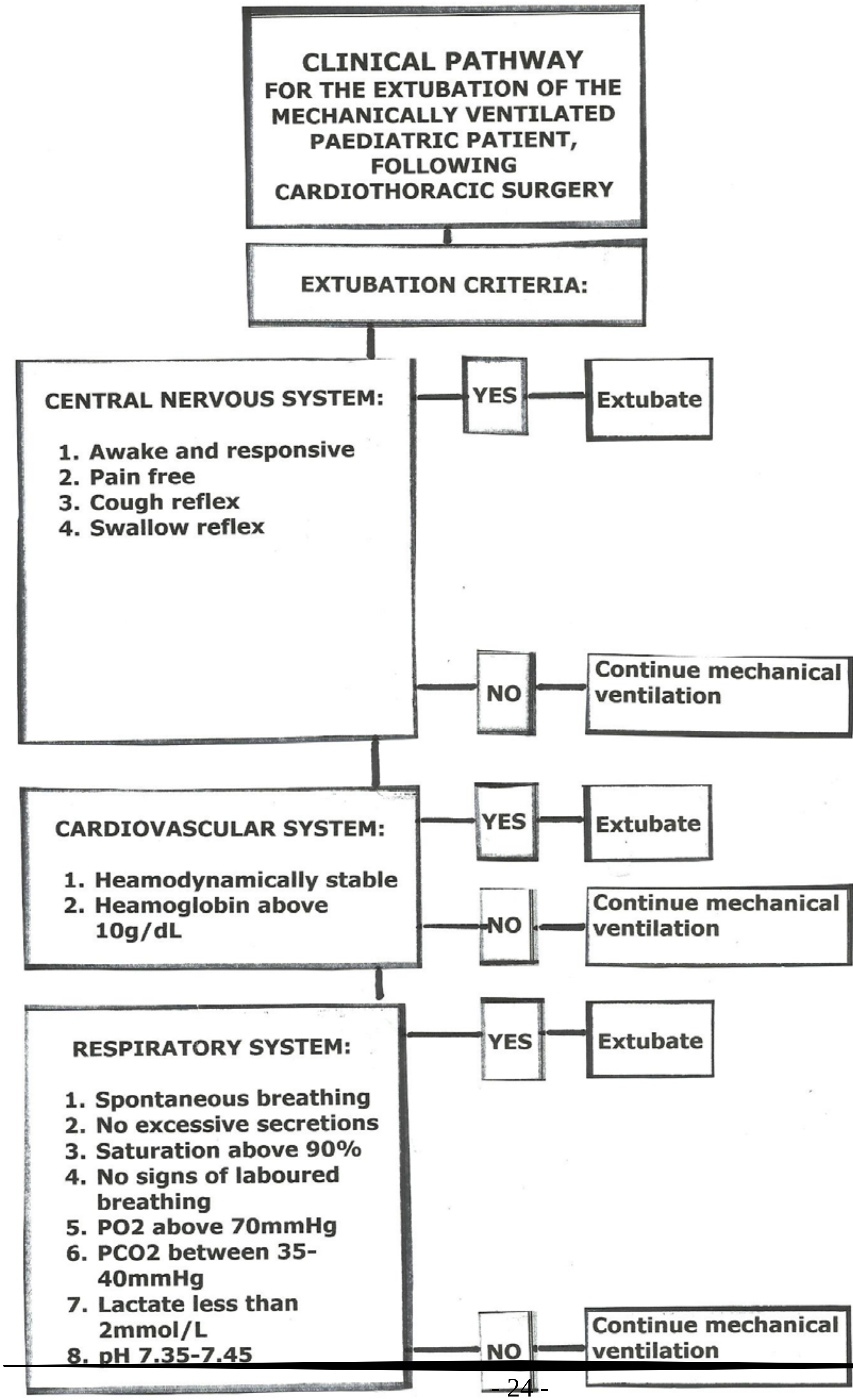
Time	Activity
08h30	General welcome and handout of documentation
08h40-09h00	Introductions and choosing of group leaders for each group, consensus on ground rules, and discussion on outcomes and expectations
09h00-09h20	**Session 1:** Individual ideas written on paper
09h20-10h10	**Session 2:** Brainstorming in groups
10h10-10h50	Coffee/Tea break
10h50-11h20	Feedback from all group leaders
11h20-12h20	**Session 3:** Consensus reached by all groups
12h20-12h30	Closure and appreciation

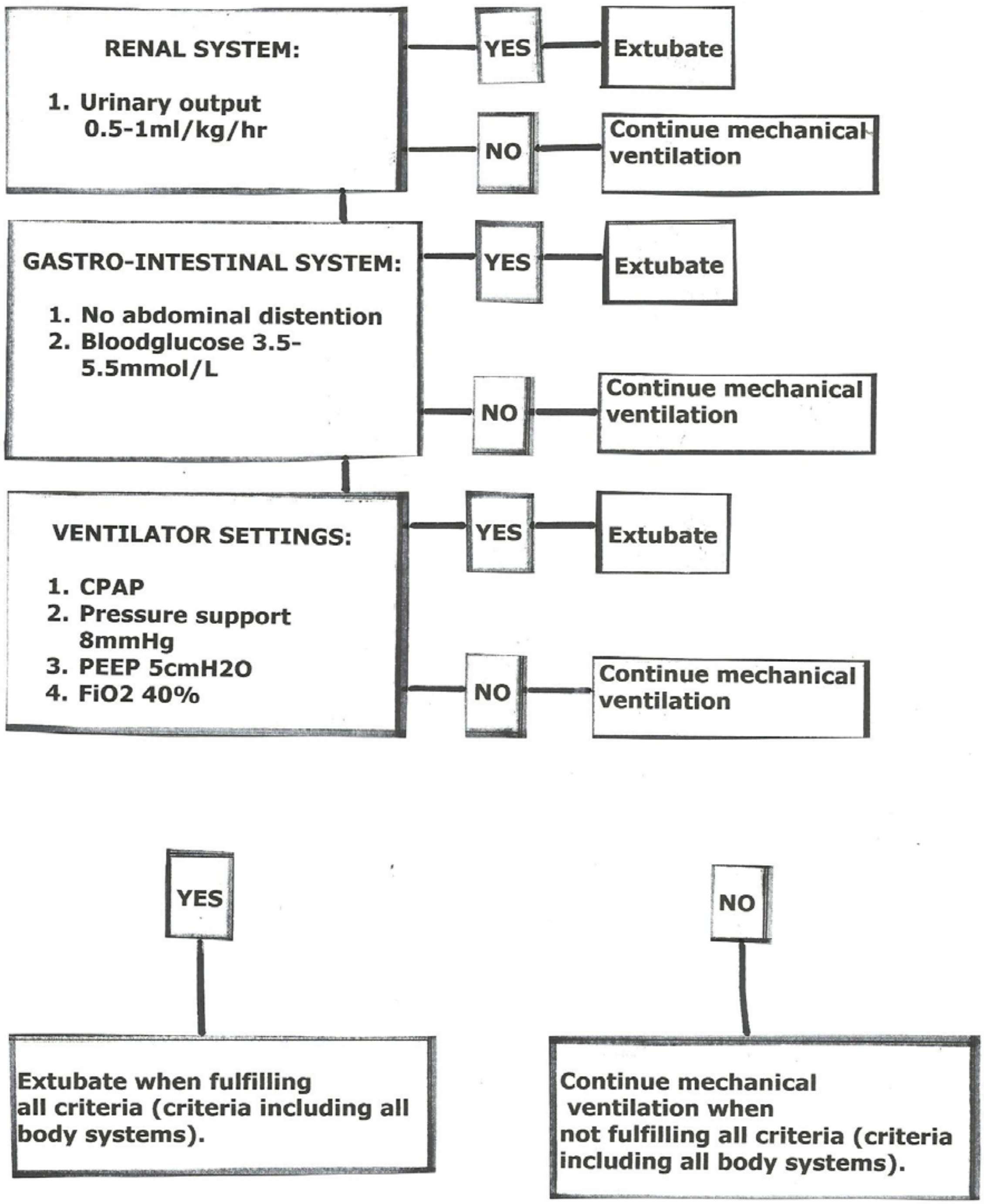
Annexure C

Clinical pathway

Annexure C1

Draft clinical pathway


CLINICAL PATHWAY
FOR THE EXTUBATION OF THE MECHANICALLY VENTILATED PAEDIATRIC PATIENT, FOLLOWING CARDIOTHORACIC SURGERY
EXTUBATION CRITERIA:
CENTRAL NERVOUS SYSTEM:
1. Awake and responsive
2. Pain free
3. Cough reflex
4. Swallow reflex
YES
Extubate
NO
Continue mechanical ventilation
CARDIOVASCULAR SYSTEM:
1. Heamodynamically stable
2. Heamoglobin above 10g/dL
YES
Extubate
NO
Continue mechanical ventilation
RESPIRATORY SYSTEM:
1. Spontaneous breathing
2. No excessive secretions
3. Saturation above 90%
4. No signs of laboured breathing
5. PO2 above 70mmHg
6. PCO2 between 35-40mmHg
7. Lactate less than 2mmol/L
8. pH 7.35-7.45
YES
Extubate
NO
Continue mechanical ventilation


RENAL SYSTEM:
1. Urinary output 0.5-1ml/kg/hr
YES
Extubate
NO
Continue mechanical ventilation
GASTRO-INTESTINAL SYSTEM:
1. No abdominal distention
2. Bloodglucose 3.5-5.5mmol/L
YES
Extubate
NO
Continue mechanical ventilation
VENTILATOR SETTINGS:
1. CPAP
2. Pressure support 8mmHg
3. PEEP 5cmH2O
4. FiO2 40%
YES
Extubate
NO
Continue mechanical ventilation
YES
Extubate when fulfilling all criteria (criteria including all body systems).
NO
Continue mechanical ventilation when not fulfilling all criteria (criteria including all body systems).

Annexure C2

Final clinical pathway

Clinical pathway for the extubation of a mechanically ventilated post cardiothorasic surgery paediatric patient

AGE SPECIFIC INDICATORS TO TAKE INTO CONSIDERATION DURING ASSESSMENT

GLASCOW COMA SCALE

EYE OPENING			
4	Spontaneous eye opening	2	Eye opening with pain
3	Eye opening to command	1	No response
VERBAL RESPONSE			
5	Coos and babbles	2	Moans to pain
4	Irritable cry	1	None
3	Cries to pain		
MOTOR REPSONSE			
6	Normal spontaneous movement	3	Abnormal flexion
5	Withdraw to touch	2	Abnormal extention
4	Withdraw to pain	1	None

(Potts & Mandleco 2007: 1059)

PAIN SCALE

FACIAL EXPRESSION	0	Relaxed	1	Grimace	2	Vigorous
CRY	0	No Crying	1	Whimper		
BREATHING PATTERN	0	Relaxed	1	Change in breathing		
ARMS	0	Relaxed/Restrained	1	Flexed/Extended		
LEGS	0	Relaxed/Restrained	1	Flexed/Extended		
STATE OF AROUSEL	0	Sleeping/Awake	1	Fussy		

(Potts & Mandleco 2007: 532)

HEAMODYNAMIC PARAMETERS / SPONTANEOUS BREATHING

AGE	TEMPERATURE (CENTIGRADE)	RESTING PULSE RATE PER MINUTE	AVERAGE PULSE RATE PER MINUTE	BLOOD-PRESSURE SYSTOLIC	BLOOD-PRESSURE DIASTOLIC	RESTING RESPIRATORY RATE	AVERAGE
NEWBORN	37.5 - 37.7	100 - 170	140	46 - 92 mmHg	38 - 71 mmHg	30 - 50	40
1 YEAR	37.5 - 37.7					20 - 30	30
3-5 YEARS	37 - 37.2	80 - 130	110	72 - 110 mmHg	40 - 73 mmHg	20 - 30	25
6 YEARS	36.7 - 36.8					16 - 22	19
10 YEARS	36.6	70 - 110	90	83 - 121mmHg	45 - 79 mmHg	16 - 20	18

(Potts & Mandleco 2007: 391)

1 ASSESS

1 ASSESS	GREEN	RED
CENTRAL NERVOUS SYSTEM		
Awake and responsive (Glascow coma scale >10 / 15)		*
Cough and swallow reflex		*
Pain free (Neonatal Infant Pain Scale)		
CARDIOVASCULAR SYSTEM		
Heamodynamically stable (Age specific parameters)		*
Heamoglobin > 10g / dL		*
RESPIRATORY SYSTEM		
Spontaneous breathing (Age specific parameters)		*
No laboured breathing (Signs and symptoms)		*
No excessive secretions (Suction < than 2-3 hrly)		
Saturation > 90%		
VENTILATOR SETTINGS		
Mode: CPAP		
Pressure Support: 8mmHg		
PEEP: 5cmH2O		
FiO2: 40%		
ARTERIAL BLOODGAS		
pH 7.35 - 7.45		
PaO2 > 70mm Hg		
PaCo2 35 - 45mmHg		
Lactate < 2mmol/L		
RENAL SYSTEM		
Urinary output 0.5 - 1ml/kg/hr		
GASTRO-INTESTINAL SYSTEM		
No abdominal distention		
Bloodglucose 3.5 - 5.5 mmol/L		

2 Plan

Equipment

EMERGENCY TROLLEY

- Oxygen connection
- Humidifier
- Bag valve mask
- Nasal canullae
- Nebulizer with prescribed medication
- Suction equipment
- Mechanical ventilator on standby

3 Implement

EXTUBATION

- Nebulize
- Oxygen via nasal canullae (2 - 4l/min)
- Chest X-ray: (As per protocol)
  - Assess for consolidation
  - Assess for any abnormality

4 Evaluate

ASSESSMENT

- Re-assess (except for ventilator settings)
- Specific:
  - Chest X-ray
  - Auscultate lungs: assess for stridor

Re-assess — After 1 hour

CODES

CODE	INDICATION	ACTION
*	Essential to comply	If all comply: Extubate If not all comply: Mechanically ventilate
Green	"Go"	Extubate
Red	"Stop"	Mechanically ventilate

5 CONTINUOUS RECORD KEEPING

Annexure D

Declaration from editor