

What factors influence successful endotracheal intubation in the critically ill morbidly obese patient in the intensive care unit?

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## **ATTESTATION OF AUTHORSHIP**

“I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person, nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.”

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## **ABSTRACT**

**Objectives:** To determine what factors influence successful endotracheal intubation in the critically ill morbidly obese patient in the intensive care unit?

**Method:** An English language literature search was undertaken using Google scholar, Medline, MD Consult, Cochrane and Cinahl (1975-2009) with the key words 'obesity', 'morbid obesity', 'ICU', 'intensive care', 'airway management', 'difficult intubation', 'positioning', 'critical care', 'bag mask ventilation'. Reference lists were examined manually to find further articles.

**Results:** Obesity has become a worldwide epidemic and morbidly obese patients are accessing intensive care services. Thirteen articles were found for analysis. The incidence of difficult intubation was greater in obese patients rather than lean patients; 15.5% and 2.2% respectively ( $p < 0.001$ ). Mallampati scoring had a correlation with ease of laryngoscopy ( $p < 0.001$ ). Mallampati score was more likely to be higher (loss of pharyngeal structures) in obese versus lean, 27% versus 13% respectively. Neck circumference was found to be an independent risk factor for difficult intubation. Ramped positioning for direct laryngoscopy provided a consistently better laryngeal exposure than the traditional sniff position. Difficult mask ventilation (DMV) was found to be present in those with a body mass index (BMI)  $>26\text{kg/m}^2$ . Difficult intubation and high Cormack-Lehane grades were significantly greater in the DMV group. The intubating laryngeal mask airway



(ILMA) was inserted with similar ease regardless of Cormack-Lehane grade. Mean arterial oxygen saturations were similar during ILMA insertion for obese and lean, 96% and 98%, respectively. In the reverse Trendelenburg position it took longer for oxygen saturations to fall to 92% during apnoea when compared with the supine position. It took twice as long for patients in the supine position to reach oxygen saturations of 97% when ventilation was re-instituted than those in the reverse trendelenburg position. In the 25 degrees head up position gives 23% higher mean oxygen tension after three minutes of pre-oxygenation.

**Conclusion:** Predictors of difficult intubation are Mallampati class and a large neck circumference for the morbidly obese. Ramped positioning provides a better laryngeal exposure for ease of intubation. With head up positioning oxygenation can be optimised reducing periods when oxygen saturation values fall. The ILMA is a safe and effective rescue device for a failed intubation.

## INTRODUCTION

Obese and morbidly obese patients are becoming more prevalent within the intensive care setting. In particular, the morbidly obese patient appears to present additional challenges and differing needs. In practice, the author has noted some potential challenges in relation to endotracheal intubation and the morbidly obese. Some of this patient population can be more challenging to successfully intubate and require additional devices to facilitate this. It has been observed that oxygen saturation values fall significantly despite usual interventions during intubation. The positioning for intubation of these patients varies somewhat depending on their size, the urgency of the intubation and the resources available to assist positioning. The author wants to explore the factors that influence endotracheal intubation for the morbidly obese population. This will include a review of the altered physiology in the presence of obesity. The knowledge gained will be used to contribute to the development of practice guidelines for the ICU in which the authors works. The new knowledge gained will be included in the orientation programme and at specific study days. The aim will be to support the practice of ICU nurses in general, improving nursing interventions and improving outcomes for the morbidly obese.

Obesity is associated with several health conditions that can be life threatening such as; heart disease, hypertension, type 2 diabetes, stroke, gallbladder disease and some cancers. The greater the BMI, the greater the risk is for disease (New Zealand Ministry of Social Development, 2009; World Health Organisation [WHO],

2004). Many of the body systems are affected by obesity. The altered respiratory physiology impacts on airway and mechanical ventilation management. They can exhibit a multitude of cardiac effects that impair cardiac function. Pharmacokinetics is affected due to the altered physiology and prescribing of medications requires modifications to address this. Nutritional requirements are a focus as obese patients can be malnourished; in particular protein deficits can exist. Positioning the obese patient and gaining vascular access are identified as challenging in practice (Marik & Varon, 1998).

Altered respiratory mechanics impact on ICU admissions the most. Respiratory failure is the leading cause of intensive care admission within the morbidly obese population (Grant & Newcombe, 2004; Pelosi et al, 1998). Morbidly obese patients are at a greater risk of hypoxia during induction of anaesthesia. Altered respiratory mechanics leads to poor oxygen reserves. A high body mass index (BMI) is associated with a more rapid reduction in oxygen saturation during periods of apnoea under anaesthesia. This can possibly be explained by the elevated metabolic rate of the morbidly obese which causes increased oxygen consumption (Dixon et al., 2005).

EI-Sohl (2004) declares that morbidly obese patients are known to have a decreased functional residual capacity (FRC). The FRC is further decreased when assuming the supine position by limiting the expiratory reserve volume. This partially explains why the morbidly obese fail to endure prolonged periods of

apnoea. El-Sohl (2004) continues to explain that oxygen tension is decreased and attempts to maintain the oxygen tension levels by bag-mask ventilation may be difficult to achieve. Due to these challenges, there is potential for unsuccessful tracheal intubation in the morbidly obese population. In the literature, awake tracheal intubation is advised when the pharyngeal structures are not visible (El-Sohl, 2004).

For the purpose of this study the terms obese and morbidly obese will have equivalency. The morbidly obese is the study population of this systematic review. However, there are some studies that have been included that pertain to obese patients and not specifically, morbidly obese patients. In some studies, authors have referred to patients as obese when in fact their BMI is indicative of morbid obesity by the New Zealand Cardiac Rehabilitation Guidelines (2002) and the WHO (2000). Other studies have actually classified their patients as obese in line with the widely utilised previous guidelines. Studies involving obese subjects, morbidly obese subjects or a combination of the two classifications have been included. The author has taken the stand point that findings in obese subjects that are significantly different to lean subjects could be extrapolated to the morbidly obese population. Findings in morbidly obese subjects could be equivalent or possibly worse. With this channel of thought obese data has been included and will be applied to the morbidly obese. The term obese when used will automatically include the morbidly obese within the discussion and to a degree the reverse too.

The author has assumed a basic level of understanding of the reader. The topic for discussion is regarding specific requirements for endotracheal intubation of the morbidly obese. Therefore it is presumed that the reader possesses foundational knowledge pertaining to standard intubating equipment and related requirements.

This systematic literature review will present the background to morbid obesity, endotracheal intubation, relevance to nursing in ICU and ICU itself. The methodology will be discussed followed by the presentation of the results from the research studies included in this review. A discussion of the findings will ensue including limitations of obesity measures. Implications for nursing and further research will be identified. A glossary of terms can be accessed after the reference list for definitions of specialised terms.

## **BACKGROUND**

### *Obesity respiratory pathophysiology*

Respiratory physiology and mechanics are altered in the presence of obesity. The identified respiratory consequences of obesity include: decreased respiratory compliance, increased airway resistance, decreased lung volumes and increased work of breathing. Respiratory failure occurs more often in the ICU setting for the morbidly obese patient (Grant & Newcombe, 2004; Pelosi et al., 1998). There is a decrease in lung base ventilation that creates poor gas exchange with a ventilation-perfusion mismatch and arterial hypoxaemia. This is explained by the reduced functional residual capacity (FRC) resulting from the abdominal contents pushing on the diaphragm (El Solh, Sikka, Bozkanat, Jaafar & Davies 2001).

The morbidly obese patient has reduced lung and chest wall compliance and the altered physiological parameters all worsen during mechanical ventilation. The mechanical work of breathing is estimated at two to four times that of the non-obese (Adams & Murphy, 2000; Bercault et al., 2004; Charlebois & Wilmoth, 2004; El Solh, et al., 2001; & Grant & Newcombe, 2004;). However, Zerah and colleagues contend that chest wall resistance is not a factor impacting on respiratory resistance and airway resistance (Zerah et al., 1993). The consequences of such findings can impact on practice strategies employed to ventilate the morbidly obese patient. Zerah and colleagues appear to be in the minority with their views on chest wall resistance. There is significantly more

literature supporting the idea that chest wall compliance does impact on the overall respiratory resistance.

The increase in work of breathing and impaired respiratory efficiency is caused by several factors such as; decreased respiratory compliance, increased mechanical pressure from the abdomen and increased metabolic demands on respiratory muscles. The ability to compensate is impaired as the respiratory reserve is reduced due to the altered physiology (Adams & Murphy, 2000).

Adams & Murphy (2000) describe airway management, specifically intubation, as increasingly challenging in the obese patient. Bag-mask ventilation and tracheal intubation is more challenging with the incidence of difficult intubation at 13%. This is due to upper airway obstruction and reduced respiratory compliance. Mask ventilation is difficult due to excessive fat tissue of the face and cheeks potentially causing gastric insufflations, increasing the risk of gastric regurgitation and aspiration of stomach contents (Adams & Murphy, 2000).

### *Epidemiology of obesity*

The prevalence of obesity continues to grow in both developed and developing countries worldwide and is now considered an epidemic. Obesity rates have climbed three times those which were observed in the 1980's in the United Kingdom, North America, Australasia, China, the Pacific Islands, Eastern Europe, the Middle East and China (WHO, 2004). Socioeconomic status alters the course

of the obesity epidemic. In developed countries obesity is frequently associated with poverty and yet in developing countries it is linked with affluence (Adams & Murphy, 2000). This epidemic is likely to be reflected in the patient population in intensive care units with more morbidly obese patients with multiple co-morbidities accessing intensive care services. Intensive care units will need to be prepared for such an outcome and plan accordingly.

The 2006/2007 New Zealand health survey revealed that an age-standardised obesity prevalence rate for adults was 25%. Although the rate of increase has slowed in recent years, this is a significant increase since 1997 when it was 19%. The prevalence of obesity varies among different ethnicities. New Zealand ethnic categories are shown in table 1 (Ministry of Social Development, 2009; Ministry of Health [MOH], 2008a).

Table 1 Prevalence of obesity in adults as a percent of total ethnic population 2006/2007

<b>Ethnicity</b>	<b>Percent of total ethnic population</b>
<b>Pacific Islanders</b>	65 %
<b>Māori</b>	43 %
<b>European/Other</b>	23 %
<b>Asians</b>	12 %

Pacific Islanders and Māori notably have higher age-standardised obesity rates than other ethnicities in New Zealand. Over the last few years only Asians have had a statistically significant increase in obesity. The United States, United Kingdom, New Zealand and Australia all have high rates of obesity. Japan has the lowest prevalence of obesity at

From: Ministry Of Health, 2008a *A Portrait of Health: Key results of the 2006/07 New Zealand Health Survey*. Wellington: Ministry of Health.



3.4% (Ministry of Social Development, 2009).

### *Obesity Classifications*

The body mass index (BMI) is a renowned measure of the relationship between height and weight. BMI is the main classification used for determining obesity in the literature, specifically in clinical and epidemiological studies. It is calculated as  $BMI = \text{body weight (in kg)} / \text{height}^2 \text{ (in centimetres)}$ . It is important to highlight that the BMI is not readily applicable to all adults (Adams & Murphy, 2000).

The BMI is the current standard system for the classification of obese and morbidly obese in New Zealand. From the literature reviewed that would seem to extend worldwide. The term severe obesity equates to morbid obesity in the studies. Obesity however seems to be interchangeable in some studies as mild obesity and moderate obesity can be deemed as obese without a severity scale.

The New Zealand MOH (2009) has defined obesity for adult New Zealanders as a  $BMI \geq 30.0 \text{ kg/m}^2$  for European, Asian and other peoples. For Maori and Pacific peoples obesity is defined as  $BMI \geq 32.0 \text{ kg/m}^2$ . There have been no ethnic variances provided for morbid obesity which is commonly defined as  $BMI \geq 40 \text{ kg/m}^2$  or  $BMI \geq 35 \text{ kg/m}^2$  in the presence of co-morbidities (MOH, 2009). Table 2

Table 2: Classification of body mass index by World Health Organisation

<b>CLASSIFICATION</b>	<b>BMI (kg/m<sup>2</sup>)</b>	<b>CLASS</b>
<b>Normal weight</b>	18.5-24.9	
<b>Overweight</b>	25-29.9	
<b>Obese</b>		
<b>Mild</b>	30 – 34.9	I
<b>Moderate</b>	35 – 39.9	II
<b>Extreme</b>	≥40	III

From: MOH, clinical trials research unit, (2009).

Clinical guidelines for weight management in New Zealand Adults. Wellington:MOH

reflects the BMI classification system.

The WHO (2000) recommends different BMI ranges for the Asia-pacific region based on risk factors and morbidities. Some ethnicities have been shown to develop co-morbidities at lower BMI's than others. It has been

suggested that Samoans have a higher cut off for obesity and Chinese and Japanese have a lower cut off for obesity with the BMI

(WHO, 2000). In New Zealand the Ministry of Health has addressed this issue and designed a BMI table that takes varying ethnicities into account (Refer Table 3).

Table 3: Proposed classification of weight by BMI in different adult ethnic groups

	New Zealand European People	Maori and Pacific Island Peoples	Asian and Indian People	Risk of co-morbidities
Underweight	< 18.5	<18.5	<18.5	Low
Healthy	18.5-25	18.5-26	18.5-23	Average
Overweight	25-30	26-32	23-25	High
Obese	>30	>32	>25	Very High

From: Ministry of Health, Clinical Trials Research Unit. 2009. *Clinical Guidelines for Weight Management in New Zealand Adults*. Wellington: Ministry of Health.

### *Significance of the study for nurses in the intensive care unit*

Endotracheal intubation occurs in the ICU and involves placing a plastic tube into the trachea so the lungs can be ventilated either by spontaneous or mandatory ventilation. There are many reasons why an endotracheal intubation can be easy. Proper positioning and skilled, experienced staff make for a well executed intubation. ICU nurses routinely set up the equipment for intubation and prepare the induction medications including follow through sedation. Nurses position the patient in a suitable position for intubation with or without the help of the intubating doctor. The nurse in charge often delegates roles for the nurses; one to assist the person intubating by passing equipment, one to do cricoid pressure, another to administer the medications for induction and someone to be a runner, document and assist as required, particularly if there is cardiovascular instability post-induction or even full cardiac arrest.

Critically ill morbidly obese patients differ in their needs to that of normal weight patients and offer specific problems for the intensive care team to address. It is known that obesity alters the physiological composition of the body affecting many body systems. Morbidly obese patients with the potential of progressing to an endotracheal intubation, are often perceived as difficult intubations and more challenging overall. The morbidly obese airway is perceived to be difficult due to the excess adipose tissue around the face, neck and airway. The adipose tissue could impinge on airway anatomy skewing structures, which complicates visualisation of the landmarks for endotracheal intubation. Adding to this perception is the preparation of several items of equipment or devices, for difficult airways and

alternative plans if first pass is unsuccessful. Positioning these patients is more cumbersome for nurses and challenging to achieve. Determining factors that influence successful endotracheal intubation in the morbidly obese will aid nurses to care for these patients better. Specific knowledge will allow for a guideline to be developed to ensure unique techniques, equipment and care are provided when planning to intubate the morbidly obese patient to optimise success and safety.

Cardiac performance is likely to deteriorate following induction by anaesthesia and should be anticipated. Obese patients could demonstrate a fall in cardiac index by 17-33% after induction and intubation, compared with a 4-11% fall in leaner patients. Post-operatively lower cardiac indices could persist in obese patients rather than normalize like their leaner counterparts (Adams & Murphy, 2000). Tsueda and colleagues (1979) coined the term “obesity supine death syndrome” after two supine morbidly obese patients experienced profound hypoxia in one case and death in the other. It has been suggested that the supine position played a major role in those two patient outcomes.

Nurses are required to predict the intubating doctor’s needs; i.e. the need for a rescue device such as a laryngeal mask airway (LMA), and patient needs such as further sedation. For nurses to do this safely and appropriately they must have sufficient specialised nursing knowledge and education. Nurses with specialised knowledge can reduce complications or at least limit them by employing preventative strategies.

In addition, out of hours there are limited medical resources and reliance on nursing staff increases noticeably. When a patient's respiratory status deteriorates, nurses assess and intervene as able until medical backup arrives.

Out of hours, when a patient's respiratory status deteriorates, nurses assess and intervene as able until medical backup arrives. The ability to support the intubating doctor is vital for optimising patient safety and due process of care. Nurses need to recognise a potentially difficult airway which will help them with the planning and set up of equipment for endotracheal intubation. Advanced nursing knowledge related to patient positioning and how that can affect laryngeal exposure during direct laryngoscopy can impact on first pass success of the endotracheal tube. In addition, the registrars (senior medical officers) working in the intensive care unit (ICU) can have a wide range of experience and skills when beginning their ICU rotation. Their intubation experience may not be significant and specifically with morbidly obese critically ill patients. The nurses are the constant within the unit and many have several years of intensive care experience behind them. Nurses are a valuable resource for our medical colleagues and collaboration can enhance patient care. Collaboration is the backbone of ICU practice to care for patients.

Currently, intensive care nurses are trained and examined at an advanced cardiac life support course every two years (Waikato District Health Board, 2006). They are taught how to complete endotracheal intubation and examined on a variety of airway management skills and use of specific equipment. A successful pass does not give the nurse licence to intubate patients within the ICU. However, it does provide the nurse with valuable knowledge and understanding of what is necessary

when a patient requires intubation. Educating intensive care nurses on how to manage intubation in the obese and morbidly obese patient is likely to improve patient outcomes and survival rates.

Patient positioning appears to be a significant factor that influences the success of endotracheal intubation in the morbidly obese population. The author's experience in the ICU is that leaner patients are positioned in the traditional sniff position for intubation, while obese through to morbidly obese had varying degrees of elevation of the head and back. This observed practice suggested that positioning made a difference, to endotracheal intubation for the morbidly obese patient. Determining the optimal position of the bed for the patient can be difficult. Awake patients are able to guide the nurse but sedated patients cannot. Positioning can be greatly affected by the patient condition i.e.; cracked ribs, respiratory failure, head injury etc. In this systematic review, the author explored positioning of the morbidly obese patient for intubation and any general positioning literature that may be present within the literature. Equally, it was important to reveal any contraindicated positions too for this patient population.

### *Purpose of the study*

The purpose of this study was to identify factors that influence endotracheal intubation in the morbidly obese population. There were specific questions that directed the search for and selection of research studies. These questions were

formulated from the clinical experience of the author pertaining to endotracheal intubation and observations in practice of the morbidly obese population.

1. Are morbidly obese patients more difficult to intubate?
2. Can a potentially difficult intubation be determined prior to intubation in the morbidly obese?
3. Should the morbidly obese patient be positioned the same as a lean patient for tracheal intubation?
4. How can oxygenation be optimized during endotracheal intubation in this patient population?
5. How can a failed intubation be rescued in the morbidly obese patient?

## **METHODOLOGY**

### *Search strategies for identification of studies*

An English language literature search was undertaken using Google scholar, Medline, MD Consult, Cochrane and Cinahl (1975-2009) with the key words 'obesity', 'morbid obesity', 'ICU', 'intensive care', 'airway management', 'difficult intubation', 'positioning', 'critical care', 'bag mask ventilation'. Literature search strategies discussed in the New Zealand Guidelines Group Handbook were employed to ensure specificity and sensitivity of evidence. This resource provided valuable information on how to conduct literature searches on a variety of databases which included the use of booleans and other advanced search strategies. Following specific guidelines on how to conduct a literature search made the process much easier and logical. A search strategy that incorporates a variety of sources is more likely to find relevant evidence (New Zealand Guidelines Group [NZGG], 2001).

### *Study selection*

Potential articles were selected by title and abstract followed by an in-depth article review for content in relation to airway management of the morbidly obese in anaesthesia and/or intensive/critical care. Research articles were manually searched including reference lists for further relevant articles not easily found on databases as endorsed by the New Zealand Guidelines Group (NZGG, 2001).



In total 93 articles were identified in the early searching phase. From those 64 articles were excluded based on overwhelming broadness to the research topic and lacking the ability for extrapolation of the data into the critical care setting. All review articles and letters to the editor were also excluded, aiming to include research studies only. Ongoing analysis of the research led to a further narrowing of the research topic. The results would have been diluted and the range of topics exceeded the size of this systematic literature review. This process saw a further 18 articles being excluded. Finally 13 articles were identified as relevant to the research question and the critical appraisal tool called the critical appraisal skills programme (CASP) analysis was conducted on each article.

It is acknowledged that there are several pieces of equipment that have to be prepared prior to intubation in the standard intensive care setting. The standard equipment for intubation was identified as not being directly relevant to the study questions and therefore is not included in this systematic literature review. Equipment excluded from the discussion will be standard intubation set up and equipment; ambubag, face mask, guedal airway, suction, oxygen, endotracheal tube, syringe, lubricating jelly, laryngoscope handle and blade, introducers, end tidal carbon dioxide monitoring etc. The following more specialised equipment, rescue devices and procedures have also been excluded; gum elastic bougie, laryngeal mask airway (LMA), fibre-optic bronchoscope for awake intubations, cricothyroidotomy and tracheostomy.

### *Quality assessment (CASP)*

Themes were identified within the literature and explored as the foundational components of the systematic review. The appraisal tool called the critical appraisal skills programme (CASP) was the critiquing framework adopted for this systematic literature review (refer to Appendix 1). The CASP involves initial screening questions followed by a questioning regime that aids analysis of the evidence presented (Public Health Resource Unit, 2007).

An evidenced based medicine working group called the Public Health Resource Unit (2007) developed guidelines to aid research analysis. The guidelines they developed were professional and extensive and became the cornerstone for the development of the CASP appraisal tools. The tools were tested in pilot groups before being adopted mostly by service administration or health care settings. In the United Kingdom, the CASP was employed to aid the National Health Service (NHS) decision makers. The aim was to acquire a skill set that enabled them to critically appraise research pertaining to clinical effectiveness, with the expectation that delivery of evidenced based care would ensue (Milne & Oliver, 1996).

The CASP provides a firm approach to evidence-based assessment. The primary goal of the CASP is to determine study validity. Each tool had three sections that comprised of questions for the critical appraisal of research; internal validity, the results and the relevance to practice (Public Health Resource Unit, 2007). There is a specific CASP tool for each of the following types of research: randomized

controlled trials, cohort studies, case control studies, diagnostic test studies, systematic reviews and economic evaluation studies. They generally have about ten questions with frequent prompts to guide the reviewer and in determining if it is appropriate to continue with the review (Bartkowiak, 2005).

Each question provided prompts to ensure all important factors were being considered e.g. p-value, power calculations. The prompts were invaluable and user-friendly when appraising the research articles. The clarity of the questions was attractive when selecting an appraisal tool. The CASP tool guaranteed a structured framework for the analysis of each article. During the process the structure facilitated identification of data for extraction. The CASP tool aided the identification of the study design and then each study was evaluated individually and comparisons were made. Following the appraisal of each study, themes were identified and explored in relation to intubation of the morbidly obese patient.

### *Exclusion of standard intubating equipment*

The previous exclusions have been determined as they are standard pieces of equipment used for intubation. The author wanted to discuss one rescue device that nurses could learn about that might be useful in the morbidly obese population. The mind set is one of keeping it simple so the rescue device is one default item. This has been done in the hope that confusion is eliminated when a rescue device is potentially or actually required as those situations can be stressful, even before an unsuccessful intubation eventuates.

## **RESULTS**

### *Description of the studies included in the systematic review*

The main themes identified in the analysis of the research studies are; pre-intubation assessment, oxygenation and positioning, endotracheal intubation and airway management rescue devices. Table 4 (p 29) presents the contribution of each study to the identified themes.

The thirteen research studies included in this systematic literature review come from all corners of the world; USA (6), Greece (1), France (4), Australia (1) and Chile (1). There were no New Zealand research studies identified during the literature search. Twelve of the research studies are cohorts and one randomised control trial (RCT). All studies explored an aspect of intubation in the obese or non-obese patient specifically within the ICU or anaesthesia environment.

The results will be presented by author in text with supporting tables as indicated. Grouping of research studies by theme was not possible due to several studies presenting data that would fall into more than one themed category.

Table 4: Individual study contribution to identified themes

	<b>Predictive tools &amp; patient characteristics</b>	<b>Oxygenation &amp; Positioning</b>	<b>Tracheal Intubation</b>	<b>Rescue Device: ILMA</b>
<b>Altermatt et al (2005) n = 40</b>		- pre-oxygenation - sitting up position - apnoea time		
<b>Boyce et al (2003) n = 26</b>		- reverse Trendelenburg - safe apnoea time - supine & back up fowler position - desaturation time		
<b>Brodsky et al (2002) n = 100</b>	- Mallampati - large neck size - Cormack			
<b>Burns et al (1994) n = 19</b>		- reverse Trendelenburg - improved breathing		
<b>Collins et al (2004) n = 60</b>		- ramped position - sniff position - Cormack		
<b>Combes et al (2005) n = 50</b>	- Mallampati - BMI	- O2 tension		- ILMA efficiency - safe - less failure with obese
<b>Dixon et al (2005) n = 42</b>		- head up 25 deg = ↑ O2 tension - faster desaturation with ↑ BMI - pre-oxygenation - safe apnoea time		
<b>Frappier et al (2003) n = 118</b>				- ILMA operator experience - intubation time - Cormack score
<b>Hekiert et al (2007) n = 63</b>	- Mallampati - large neck size - Cormack		- obesity/BMI - difficult laryngeal exposure	
<b>Juvin et al (2003) n = 129</b>	- Mallampati	- pre-oxygenation O2 tension - SaO2 lower in Obese	- difficult intubation - difficult laryngoscopy	
<b>Langeron et al (2000) n = 1502</b>	- DMV: BMI, age, snoring, beard, no teeth		- DMV - difficult intubation - Cormack	
<b>Mallampati et al (1985) n = 210</b>	- Mallampati		- laryngeal views - intubation - obesity	
<b>Voyagis et al (1998) n = 1833</b>	- BMI - large tongue - Mallampati		- difficult intubation & obesity classes	

## *Study Designs*

The studies consisted of cohort studies with the exception of one randomized control trial (RCT). Cohort studies come under the observational analytical umbrella. Bennet & Emberson (2008) stated that generally, they attempt to quantify a relationship between two factors. It analyses the effect an intervention or exposure has on an outcome. A cohort study is generally prospective in nature as the outcome is determined after the exposure or intervention. However, some cohort studies are retrospective in design. A cohort study is often used to predict risk factors of an outcome. Data is usually extracted from a group exposed or not exposed to the factor of interest. In this case the factor of interest was morbid obesity. Cohort studies are an appropriate method for exploring intubation and airway management in the morbidly obese, since the study group should have the disease or condition present. The cohorts involved following a group of obese patients with a number of treatment interventions, i.e. position change, or comparing responses between an obese cohort and a lean cohort to treatment interventions/predictive scores. There are several advantages of a cohort study. They are ethically safe, subjects can be matched, and they are easier and cheaper than a RCT. In a cohort study timing can be established as well as directionality of events. In addition, the eligibility criteria and outcome assessments can be standardised (Bennet & Emberson, 2008).

Cohort studies have disadvantages attached to them in principle. Controls can be challenging to identify in cohort studies and blinding may not be achievable. On

occasion, the exposure itself may be linked to a sleeping confounder. There is no randomisation within this design. When using a cohort design for a rare disease or condition sample sizes need to be large or require long follow-up periods (Bennet & Emberson, 2008).

The numbers of morbidly obese patients entering ICU's per year is unknown as it is not included in the data collected for each admission for unit statistics. This complicates the assessment of prevalence of morbidly obese patients in the ICU. The disadvantage of using a cohort design for this population, is identifying a large enough sample size, without increasing exposure to confounding as a consequence of time, such as a change in clinical practice. If a study takes too long, the results may have become irrelevant or out dated as the same data may have already been produced by others. If it takes an excessive length of time to enrol a sufficient number of subjects then study subject numbers may be sacrificed for time saved. In this instance, results will be diluted and less valid. Strong correlations and other statistical significance may not be able to be demonstrated due to low power. Whereas, with sufficient study subjects statistical significance can be proven, making the research valuable.

The gold standard of the RCT is not always possible when testing live human subjects. RCTs are the best for studying the effect of an intervention and have several advantages. There is an unbiased distribution of confounders, blinding is more likely to be achieved and randomisation affords statistical analysis. Equally,

there are some disadvantages to a RCT. They are renowned for being financially expensive and time consuming, require volunteers and present ethical problems at times (Bennet & Emberson, 2008). Establishing blinding was not possible in most studies justifying the choice of a cohort design. Blinding can help reduce any potential bias when used.

### *Study Participants*

The studies participants were all adults aged 18 years and over, any ethnicity and any gender. Many were undergoing general anaesthesia for an elective procedure, some specifically for bariatric surgery. The studies participants were obese or morbidly obese. Variations on the BMI classifications were evident in some studies deferring from the traditional widely accepted classifications by the WHO and possibly tailoring BMI ranges to suit their own study designs. As mentioned before, the most evident disparities appear to occur with classifying the obese and morbidly obese population. Altering obesity parameters is understandable although it does make analysis more challenging and application of findings may be skewed as a result.

### *Study Interventions*

Study interventions involved many measurements. This involved measuring the oxygen tension at specific times throughout the intubation sequence including apnoea periods and in various positions (supine, sitting, head elevation and reverse Trendelenburg). Laryngeal exposure was assessed in relation to positioning and pre-intubation predictive tools and patient characteristics. The



ILMA effectiveness and ease of use was measured by successful endotracheal intubation with the rescue device.

### *Study Outcome Measures*

Four main outcomes in relation to intubating the morbidly obese patient were identified from the literature. The first outcome was the identification of predictive tools and patient signs signalling a potentially difficult intubation. The second outcome was the identification of specific patient positions which improved laryngeal exposure for direct laryngoscopy and intubation. The third outcome was related to the ability to optimise oxygenation during induction, lengthen the time taken for oxygen saturation values to fall and decrease the time taken for recovery from desaturation. The final outcome was the identification of a suitable default rescue device for a failed attempt at endotracheal intubation.

### *Methodological quality of the studies reviewed*

The single RCT study (Dixon et al., 2005) methodology was sound with a power calculation done and potential bias was corrected for. The authors were unable to blind the study due to the nature of the measurements as the intubating doctor would always know what position the patient was in. There were no power calculations done in the cohort studies. The studies would have been much bigger if there had been. The cohort studies had varying numbers of study subjects, some quite small with outcomes only identifying weak correlations or lacking statistical significance. There were three cohort studies (Altermatt et al., 2005;

Boyce et al., 2003 & Burns et al., 1994) with less than 50 participants, seven studies (Brodsky et al., 2002; Collins et al., 2004; Combes et al., 2005; Frappier et al., 2003; Hekiert et al., 2007; Juvin et al., 2003 & Mallampati et al., 1985) had between 50-500 participants and finally two studies (Langeron et al., 2000 & Voyagis et al., 1998) had enrolled more than 1500 study participants. A list of the number of participants each study had can be found in Table 4 (p.29). A power calculation may have guided them to a larger number of study subjects in particular the smaller studies, which may have led to statistical significance and stronger correlations. Due to the study topic, waiting for sufficient numbers of study subjects may have taken too long to justify.

Some studies (Collins et al., 2004) were done in specialised bariatric hospitals where there was a plethora of potential study subjects which afforded significantly larger study groups. General hospitals did not have the same population to select from which was restrictive for them. In those instances, the study periods were significantly longer as a result. By using bariatric specialised hospitals there is the potential risk of bias sampling being introduced, as patients undergoing elective procedures may have fewer co-morbidities than those having surgery in a tertiary teaching hospital. One study (Hekiert, Mick & Mirza, 2007) acknowledged that 30 subjects had missing data. The Cormack Lehane grades were missing for half of the study population. This highlighted a major flaw in their methodology for collecting data. Findings pertaining to the Cormack Lehane grading had to be discounted when analysing the data as findings would not have been reliable or valid.

## *Study Results*

Juvin et al (2003) conducted a prospective study of 129 obese (BMI >35) and 134 lean (BMI<30) patients to determine if difficult intubation is more frequent in obese or lean patients by using the intubation difficulty score (IDS). All patients were able to be intubated. The incidence of difficult intubation was greater in the obese patients rather than the lean patients; 15.5% and 2.2% respectively (p <0.001). The incidence of difficult laryngoscopy (Cormack-Lehane class III or IV) was parallel at 10% for each group (p= not significant). The incidence of co-morbidities was higher in the obese rather than lean group. Pre-oxygenation and Spo2 value after pre-oxygenation was similar for each group. However, the minimal value of Spo2 during the intubation was noted to be higher in the lean rather than the obese group. During intubation, the obese patients (n=20) with an IDS greater than five had a mean minimal SPO2 value of 89% +/- 1-0% (range, 50%-99%) whilst it was 96% +/- 7% (range, 64%-100%) in the obese patients that had an IDS value <5 (P= 0.0006). Time taken to intubate was not measured in this study.

A univariate analysis was done on the obese group only to determine risk factors for difficult intubation in this population. Obese patients with an IDS value <5 and >5 were compared. A multivariate analysis was done with the significant variables of the univariate analysis. The multivariate analysis determined that a Mallampati score of III or IV was an independent risk factor for difficult intubation in obese patients, whereas obesity (BMI) was not. The sensitivity of the Mallampati score was 100% and 85% , its specificity was 74% and 62%, its positive predictive value

was 8% and 29% and its negative predictive value was 100% and 96% in lean and obese patients, respectively (Juvin et al, 2003).

One cross sectional study by Mallampati et al (1985) comprised of 210 subjects that were recruited to compare preoperative views of faucial pillars, soft palate and base of tongue with direct laryngoscopy view of glottic exposure under general anaesthesia. The classing of the visualised pharyngeal structures became known as the Mallampati classification from this study. Initially, Mallampati (1985) identified three classes and then Samsoon & Young (1987) identified a fourth class which is now known as the modified Mallampati classification. Class three still had visibility of the soft palate whereas, class four occurs when there is no soft palate visible (refer figure 1).

Figure 1 Pictorial classification of the pharyngeal structures seen with mouth open, modified from Mallampati et al 1985

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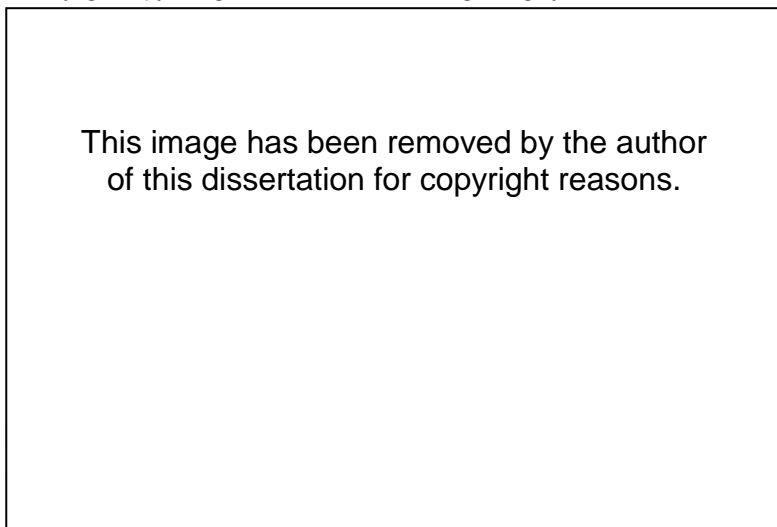
From: Samsoon G., & Young, J. (1987). Difficult tracheal intubation: a retrospective study. *Anaesthesia*, 42; 487-490.

The Cormack and Lehane grading was used to classify the degree of glottic exposure upon direct laryngoscopy (refer figure 2, p 37). The authors were trying to establish a relationship between pre-operative views and degree of glottic exposure on laryngoscopy in an attempt to predict difficult intubation. The results

demonstrated a significant correlation between the ability to visualise pharyngeal structures and the ease of laryngoscopy (chi-square:  $p < 0.001$ ).

In class 1 of the modified Mallampati classification, (n=155) all three pharyngeal structures were seen and they were all easy laryngoscopic visualisations with 80.6% grade 1 and 19.3 % grade 2. There were no difficult intubations in this group. In class 2 (n=40) where the uvula was masked by the base of the tongue, laryngoscopy was easy (grade 1 or 2) in 26 patients (65%) and difficult (grade 3 or 4) in 14 patients (35%). In class 3 (n=15) there were no grade 1 views and only one patient (6.6%) had an easy view at a grade 2. All other patients (n=14) had difficult views of either grade 3 (60%) or grade 4 (33.3%).

Figure 2 Illustrates a difficult airway defined by the laryngeal view on laryngoscopy using the Cormack & Lehane grading system



From: Samsoon, G., & Young, J. (1987). Difficult tracheal intubation: a retrospective study. *Anaesthesia*, 42; 487-490.

obesity had easy views (Mallampati et al, 1985).

All edentulous patients had easy views of a grade 1 or 2. Of the 12 patients with an overbite, nine were easy views and three were difficult (grade 3 or 4). Of the four patients with restricted neck mobility, two had an easy view and two had a difficult view. All four patients undergoing gastroplasty for

A prospective study of 1833 consecutive adults done by Voyagis, Kyriakis, Dimitriou & Vrettou (1998) explored the value of the oropharyngeal (OP) Mallampati classification in predicting difficult laryngoscopy among obese patients. They were categorised into three groups; absence of obesity with BMI < 30 (n=1734), moderate obesity BMI 30-40 (n=87) and morbidly obese BMI >40 (n=12). Of the study subjects, 152 proved to be a difficult intubation (8.3%).

Loss of posterior pharyngeal structures was demonstrated in 13.7% in the absence of obesity group versus 27% of the overall obese group. These OP findings were significantly different. The difference in difficult intubation between moderate obesity and morbid obesity were similar, therefore were grouped together as similar. The risk of difficult intubation was greater in the obese versus the absence of obesity group; 20.0% versus 7.6% respectively,  $p < 0.001$ , RR = 2.2, 95% confidence interval 1.7. In the presence of obesity it may provide false positive results when using the Mallampati score (Voyagis, Kyriakis, Dimitriou & Vrettou, 1998).

Brodsky, Lemmens, Brock-Utne, Vierra & Saidman (2002) studied 78 women and 22 men who were morbidly obese, aged between 36-51 years old. They studied the subjects pre-operatively and during tracheal intubation. Forty-four patients were suspected of or had a confirmed history of obstructive sleep apnoea (OSA) whilst 56 patients had no evidence of OSA. The median neck

circumference was 46 cms, the sternomental distance was 14 cms and the thyromental distance was 9.5 cms.

Table 5: Depicts the number of patients in each of the airway classes

Airway Classes	Population (n)
<b>Mallampati Class</b>	
1	30
2	37
3	32
4	1
<b>Cormack Lehane Grade</b>	
1	75
2	16
3	9
4	0

From Brodsky et al. (2002). Obesity & tracheal intubation. *Anaesthesia & Analgesia*, 94; 732-736.

Mallampati scores revealed even distribution of patients between class I-III and only one class 4.

During the initial laryngoscopy, the view of the larynx was deemed a grade 1 in the majority of patients, with descending numbers in grades 2 & 3 and zero grade 4 laryngeal views (refer table 5). In 92, 5 and 2 patients the trachea was intubated on the first, second and third attempts respectively. There was one failed intubation with direct laryngoscopy.

In 97 patients the tracheas were intubated by an anaesthetic registrar and three patients by the anaesthetic consultant. There were 12 patients whom were classed as difficult intubations. Patient characteristics were tabled into easy versus problematic intubation. Using logistic regression analysis, neck circumference was the only patient characteristic that had a significant effect on the probability of problematic intubation ( $p = 0.02$ ). Adding other characteristics to the model did not detect a significant improvement. The logistic regression model predicts that the odds of a problematic intubation in a particular patient with a neck circumference 1cm larger than that of another patient are 1.13 (95% CI, 1.02 to 1.25) times the odds of the patient with a 1 cm smaller neck circumference. Therefore a 40 cm

neck circumference carries a 5% probability of problematic intubation and at 60 cm the probability rises to 35%.

A larger neck circumference was associated with men ( $p < 0.001$ ), a higher Mallampati score ( $p = 0.0029$ ), grade 3 views during direct laryngoscopy ( $p = 0.0375$ ) and OSA ( $p = 0.0372$ ) (Brodsky, Lemmens, Brock-Utne, Vierra & Saidman, 2002).

Hekiert, Mick & Mirza (2007) prospectively evaluated 63 obese patients with a BMI  $>30$  pre-operatively and during direct laryngoscopy. They wanted to identify pre-operative predictors of difficult laryngoscopy and any relationships that could be linked to obesity. A visual analog score (VAS) 1-10 was used to grade the laryngeal exposure, a score of at least 3 was considered difficult. VAS score correlated with the Mallampati scores highly positive ( $p < 0.001$ ) and also the Cormack-Lehane score ( $p < 0.001$ ). The correlations were not gender specific. Correlation between the VAS score and BMI was demonstrated ( $p < 0.007$ ) but only weakly for weight ( $p = 0.05$ ) and neck circumference ( $p = 0.07$ ).

Correlation of patient characteristics and the Mallampati score was determined to have a high positive correlation in three categories; neck circumference ( $p < 0.001$ ), weight ( $p < 0.001$ ) and BMI ( $p < 0.001$ ). Again this was not gender specific. The Mallampati scores did correlate with the Cormack-Lehane scores ( $p < 0.009$ ), with a significantly stronger correlation with women. When evaluating patient



characteristics and the Cormack-Lehane score for correlation statistical significance was lacking. A weak positive correlation was seen with BMI ( $p=0.09$ ) and was seen in men only.

It was demonstrated that the obese patients had significantly higher Mallampati scores ( $p<0.001$ ) and VAS scores ( $p<0.006$ ) when compared with their non-obese counterparts. A neck circumference of at least 40cm is significantly higher in the obese subjects than in the non-obese patients (93% versus 36%;  $p <0.001$ ). Obese patients were 6.5 times (OR 6.49) more likely to have difficult laryngeal exposure (DLE) which was a VAS score of at least 3. Patients with a Mallampati score of 2 or more was associated with DLE when compared to those patients with a score of one (78% versus 24%;  $p<0.001$ ). They were 10 times more likely to have DLE relative to those with a score of one (OR 10.27). Only the Mallampati scoring (less than 2 versus more than 2) was found to be a significant independent predictor in the multivariate model after logistic regression analysis ( $p=0.004$ ; OR 9.4).

Unfortunately there was data missing from 30 patients in this study. The missing data was the Cormack Lehane grades. Given this gross mishap in their data collection this author has excluded any results pertaining to the laryngoscopic view as reliability and validity of those results is questionable.

Figure 3 ramped position with external auditory meatus aligned with the sternal notch along a horizontal plane

Figure 4 traditional sniff position with 7cm head elevation

These images have been removed by the author of this dissertation for copyright reasons.

From: Levitan et al (2003) Head elevated laryngoscopy position: improving laryngeal exposure during laryngoscopy by increasing head elevation. *Annals of emergency medicine*, (41)3:322-330.

Bias and/or confounding will be an issue for those results. Data pertaining to specific patient characteristics has been included as those findings bear relevance to the research question formed by this author. Lack of relevancy would certainly have excluded this study entirely (Hekiert, Mick & Mirza, 2007).

One study by Collins and colleagues (2004) compared ramped versus the sniff position for optimal laryngeal exposure in the obese (refer figures 3 and 4). Eight men and 52 women participated in the study. There were no differences in demographic parameters between each group. All tracheas were intubated successfully first pass. Mean intubation time was 21.1 secs +/- 5.4 secs in group one (sniff) and 20.6 secs +/- 7.6 in group two (ramped). There was no statistical difference between the groups pertaining to thyromental distance, sternal distance.

However, the inter-incisor gap was smaller in group one patients and neck circumference was larger in group two patients ( $p = <0.05$ ). The laryngoscopy view

score as described by using Cormack and Lehane grading are displayed in table 6. The difference in the graded view on laryngoscopy was significantly different ( $p = 0.037$ ) between the two groups. The ramped position consistently provided a better laryngeal view (Collins, Lemmens, Brodsky, Brock-Utne & Levitan, 2004).

Table 6 Comparison of the Cormack-Lehane grades between the sniff and ramped positions

<b>CORMACK-LEHANE GRADE</b>	<b>GROUP ONE SNIFF POSITION (n)</b>	<b>GROUP TWO RAMPED POSITION (n)</b>
<b>1</b>	18	29
<b>2</b>	9	3
<b>3</b>	2	1
<b>4</b>	2	0

From: Collins et al, (2004), Laryngoscopy and morbid obesity: a comparison of the “sniff” and “ramped” positions

Langeron et al (2000) explored the incidence of difficult mask ventilation (DMV) and the factors associated with it. The prospective study involved a total of 1,502 patients that were undergoing general anaesthesia. DMV was characterised by six possible difficulties and its occurrence (refer to table 7). The ability to mask ventilate a patient impacts on the overall intubation success in several ways.

An ideal seal will ensure adequate pre-oxygenation takes place and the ability to bag-mask ventilate a patient can be crucial if the intubation attempt is unsuccessful whilst the patient remains apnoeic, sedated and relaxed.

Pre-operative assessments by the anaesthesiologist only revealed 17% (95% CI, 9-26%) of the actual DMV patients and 4% of the DMV patients were predicted to be DMV's pre-operatively. The predictions are subjective in nature and had a sensitivity of 0.17 and a specificity of 0.96. Some variables (mouth opening,

Table 7: Difficulties experienced during mask ventilation of 75 patients (~5%)

VARIABLE	N (%)
Significant gas leak from mask	42 (56%)
Two-handed mask ventilation required	36 (48%)
Needed to use oxygen flush valve >twice	24 (32%)
No evidence of chest movement	18 (24%)
Spo2 < 92%	11 (15%)
Change of operator required	9 (12%)
One variable occurred	38 (51%)
Two variables occurred	21 (28%)
Three or more variables occurred	16 (21%)

receding mandible and use of paralysing agents) were not significantly different between the two groups.

In the multivariate analysis, several factors were identified to be significantly associated with DMV; age older than 55 years, BMI >26kg/m<sup>2</sup>, lack of teeth, history of snoring and presence of a beard.

These five risk factors were

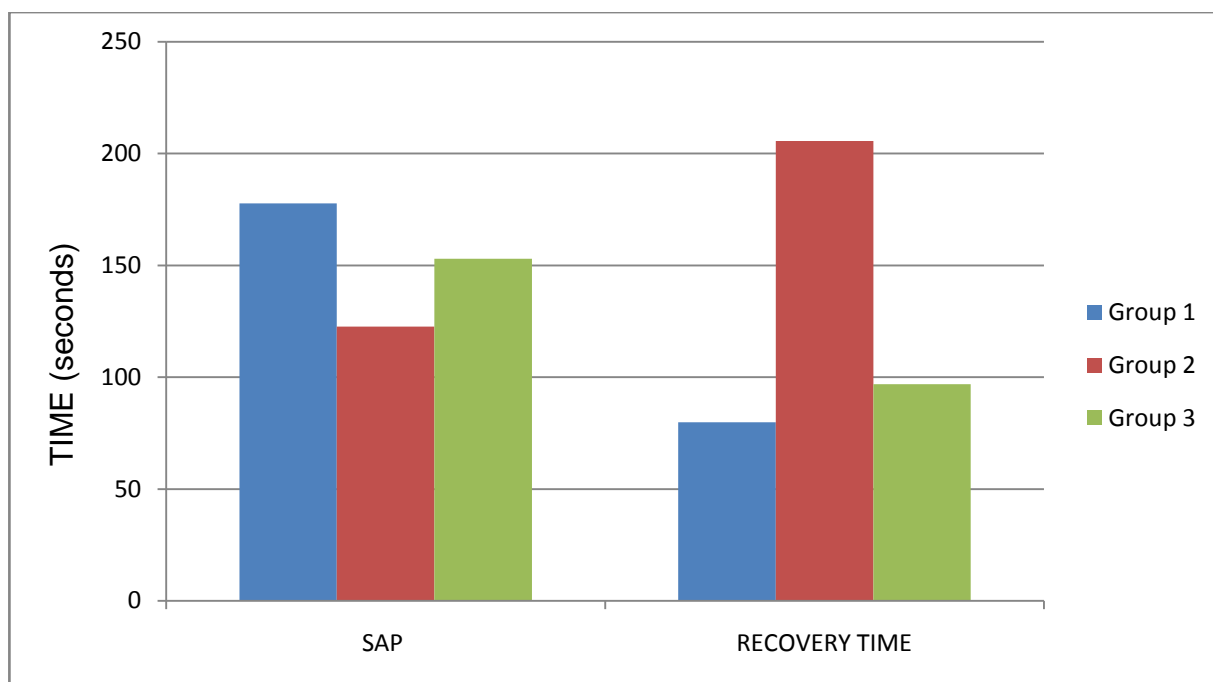
identified as predictors of DMV. Of those patients intubated (n=1,374), the occurrence of difficult intubation and Cormack-Lehane scores III or IV were significantly greater in the DMV group (Langeron et al, 2000).

A study conducted by Boyce and colleagues (2003) investigated the effect position had on oxygenation with the aim of determining optimal positioning for induction that minimised the risk of hypoxaemia in the morbidly obese. Twenty-six morbidly obese patients were randomly assigned into one of three position groups; 1) 30 degrees reverse Trendelenburg, 2) supine, 3) 30 degrees back up Fowler. After intubation patients were ventilated for five minutes and then disconnected from the circuit. The oxygen saturation was monitored and the time for SaO<sub>2</sub> to fall from 100% to 92% was recorded at the safe apnoea period (SAP). At a SaO<sub>2</sub> of 92%, manual ventilation resumed and the patient was placed back on the ventilator circuit.

There were no statistically significant differences in the physical characteristics of the three groups. Bag mask ventilation, direct laryngoscopy and intubation did not present difficulties in any patients.

Group one (reverse Trendelenburg) took 55 seconds longer for the SaO<sub>2</sub> to fall to 92% (178 sec total) compared to group two (supine) which only took 122 seconds in total (refer to table 8). The back up Fowler (group 3) took 30 seconds longer to reach the desaturation point of SaO<sub>2</sub> 92% than the supine (group 2). Time in seconds from desaturation measured at SaO<sub>2</sub> 92% until a SaO<sub>2</sub> of 97% was measured. The supine (group 2) took at least twice as long (206 seconds) to recover than either the reverse Trendelenburg (group 1) or back up Fowler (group

Table 8: Depicts the safe apnoea period (SAP) in seconds and the recovery time which is the time in seconds for the oxygen saturation to reach 97% once ventilation was re-established



From: Boyce, Ness, Castroman & Gleysteen, 2003.

3). In fact, the reverse Trendelenburg (group 1) had the fastest recovery time at 80 seconds, quickly followed by the back up Fowler (group 3) with 100 seconds ( $p < 0.001$ ). When using the SAP as the dependent measure, a negative correlation with BMI which explains clinical observations that the greater the obesity, the faster the progression of hypoxaemia (Boyce, Ness, Castroman, Gleysteen, 2003).

Dixon et al (2005) conducted a randomised controlled trial that measured oxygen saturation and the desaturation safety period after 3 minutes of pre-oxygenation in 42 morbidly obese patients (BMI >40) and were randomly assigned to supine or 25 degrees head up position. The power of the study was calculated using the time to a desaturation of 92% as this was the key outcome measurement. It was calculated that 42 patients were needed to be randomly assigned to one of the two

patient position groups to express a 95% probability of detecting a 30 second difference between groups with a power of 0.8.

There were no significant differences between the patients of each randomly assigned group and any potential confounders were controlled for. After induction of anaesthesia, the desaturation safety period (DSP) was 201 +/- 56 s in the pre-oxygenated 25 degrees head up position compared with the supine group at 155 +/- 70 s which was a significantly shorter DSP ( $P = 0.02$ ). The 46 s difference between groups is clinically significant, allowing additional time before falling to a saturation of 92%. Linear regression multivariate analysis revealed the position for pre-oxygenation explained the significant variance in the DSP when controlled for age, sex and BMI ( $P = 0.03$ ). A higher BMI did reduce the time taken to desaturate to 92% ( $P = 0.03$ ). The DSP was strongly related to the oxygen tension achieved after pre-oxygenation ( $P = 0.001$ ). Position for pre-oxygenation did not impact on the lowest oxygen saturation recorded after active ventilation commenced or the time taken to reach an arterial oxygen saturation of 97%.

Those randomly placed in the 25 degrees head-up position exhibited a 23% higher mean oxygen tension after three minutes of pre-oxygenation. Two independent factors predicted a higher oxygen saturation after pre-oxygenation which were female sex and the 25 degrees head up position ( $P = 0.004$ ). The mean oxygen tension after pre-oxygenation was lower in men than women, 350 +/- 116 mmHg and 424 +/- 99 mmHg, respectively ( $P = 0.04$ ). Forty-two percent of the men

randomly assigned to the supine position did not reach an oxygen tension of 300 mmHg after pre-oxygenation ( $P = 0.02$ ). Blood gas results were not significantly altered in relation to patient position. The oxygen tension in the 25 degrees head up patients tended to be higher 90 seconds after induction (Dixon et al, 2005).

A Chilean study by Altermatt, Munoz, Delfino & Cortinez (2005) wanted to explore the notion that the reduced functional residual capacity present in obesity which worsens when in a supine position, might also effect pre-oxygenation and tolerance to apnoea. They randomly assigned 20 obese patients ( $BMI \geq 35$ ) into group one (sitting) and 20 obese patients into group two (supine) who were undergoing elective surgery with general anaesthesia. Pre-oxygenation was achieved by eight deep breaths within one minute on 10 litres/minute of oxygen. After each patient was intubated, they were left apnoeic and disconnected from the anaesthesia circuit until oxygen saturation values fell to  $SaO_2$  90%. Time taken for oxygen saturation levels to fall was recorded aswell as oxygen tension before (baseline) and after pre-oxygenation.

Patient characteristics between each group were unremarkable proving to be a good match of groups. There were no differences between each group, results for oxygen tension, carbon dioxide tension, oxygen saturation, alveolar/arterial  $Po_2$  difference and the ratio of arterial oxygen tension to inspired fraction of oxygen. Time to desaturate to  $SaO_2$  90% was longer in group one (sitting position) than in



Figure 5: Depicts the various bed head elevations for the test positions



group two (supine position) 216 versus 164 respectively,  $p < 0.05$  (Altermatt, Munoz, Delfino & Cortinez, 2005).

Burns and colleagues (1994) conducted a study to explore the optimal position for intubated patients with obesity, ascites or abdominal distention.

They wanted to determine the body position that optimises breathing pattern in spontaneously breathing, intubated patients with a large abdomen. Nineteen intubated

From: Burns et al, (1994). Effect of body position on spontaneous respiratory rate and tidal volume in patients with obesity, abdominal distention and ascites. *American Journal of critical care.* (3)2: 103.

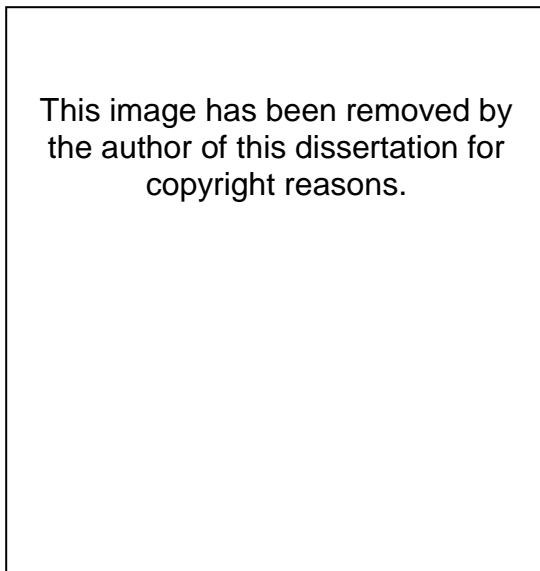
patients with abdominal distention, ascites or obesity on continuous positive airway pressure or pressure support ventilation mode, were studied in four different positions (refer to figure 5) for five minutes in each position before data was collected.

The study subjects were convenience sampled over a two year period. Of the

nineteen patients, 14 had a large abdomen from obesity. All positions were compared with 90 degrees. The mean respiratory rate was lower at 45 degrees compared to 90 degrees (mean respiratory rate 21.5 Vs 25,  $p=0.0003$ ). The mean respiratory rate was lower at reverse Trendelenburg at 45 degrees compared with 90 degrees (mean respiratory rate 21 Vs 25,  $p=0.0008$ ). The difference between 0 and 90 degrees was insignificant. The mean tidal volume was higher in the reverse Trendelenburg at 45 degrees compared with 90 degrees, (mean tidal volume 573mls Vs 507mls,  $p=0.004$ ). No significant difference was found in tidal volume between the 90 and 0 degrees and 90 and 45 degrees positions.

Upon questioning patients in each position “how do you like this position?” it was determined that the 45 degree and reverse Trendelenburg at 45 degrees were the preferred patient positions.

Figure 6: The intubating laryngeal mask airway



Frappier et al (2003) studied the effectiveness of the intubating laryngeal mask airway (ILMA) in morbidly obese patients booked for bariatric surgery. Figure 6 illustrates a typical ILMA. Once anaesthetised the laryngeal view was graded by the first observer using Cormack-Lehane scoring. Then the ILMA was inserted by a second observer. The study successfully

enrolled 118 patients. There was high female representation (84%) which is usual for patients undergoing bariatric surgery. Twenty-two staff who participated in the

intubations comprised of staff anaesthesiologists and nurse anaesthetists. Successful endotracheal intubation with the ILMA occurred in 114 subjects. The four failed intubations were due to unsuccessful attempts at passing the tracheal tube through the trachea. One of those patients was a grade three on laryngoscopy. There was no incidence of difficult mask ventilation. Mild hypoxia (<95% SpO<sub>2</sub>) occurred in 37 patients and no episodes of severe hypoxia (<90% SpO<sub>2</sub> for >1 minute) occurred.

Endotracheal intubation with the ILMA was not different between obese patients with high grade (3 or 4) Cormack-Lehane and those with a low grade (1 or 2). However, it was noted that high grade Cormack-Lehane scores were associated with a longer time for ILMA insertion compared with the low grades. There were no differences noted between experienced and inexperienced intubators with regards to time taken to establish LMA and tracheal intubation (Frappier et al, 2003).

Combes et al (2005) conducted a comparative study of the intubating laryngeal mask airway in morbidly obese and lean patients. This prospective study enrolled fifty morbidly obese and 50 lean patients with mean BMI's of 42 and 27, respectively. The airways were assessed after induction of general anaesthesia on ability to ventilate, intubate and manage airway, airway characteristics, use of adjustment manoeuvres, number of failed tracheal intubation attempts, total duration of airway management and scoring of difficulty using the visual analog scale. Patient characteristics were similar excluding the weight and BMI.

Momentary drops in arterial oxygen saturations below 90% were observed in four obese patients prior to ILMA insertion. The mean arterial oxygen saturations were 96% and 98%, for obese and lean patients, respectively. Safety of the ILMA use in both groups appeared similar as all patients were able to be adequately ventilated. Interestingly, the obese group demonstrated a lower proclivity for Chandy adjustment maneuvers ( $p<0.02$ ) and failed blind tracheal intubations ( $p<0.01$ ). The author hypothesised that this could be due to reduced pharyngeal area and volume due to obesity as seen in magnetic resonance imaging. These reinforced lateral structures with fat could guide the ILMA into place. It could explain why a good ILMA seal is seen more often in obese rather than lean patients (Combes et al, 2005).

## DISCUSSION

### *Pre-intubation assessment of the airway: predictive tools and patient characteristics*

The first theme identified from the research studies was that of pre-intubation assessment of the airway. This theme comprises predictive tools and patient characteristics. Predictive tools are used pre-intubation in an attempt to predict potentially difficult intubations to allow for time to prepare particular equipment and have experienced intubators present. Certain patient characteristics have been linked to potentially difficult laryngoscopy views or intubation. Samsoon and Young (1987) highlight that for a successful intubation a patient needs to have sufficient neck mobility to achieve a good position for laryngoscopy. For the laryngoscope blade to fit in the mouth there needs to be adequate mouth opening. By combining predictive tools and patient assessment pre-operatively, the intubator can gain an idea of the patients' bite, size of the oropharyngeal structures, size of the tongue and overall risk of difficult intubation (Samsoon & Young, 1987).

The most common predictive tool for pre-intubation assessment of the airway is the assessment of the oropharyngeal structures known as the Mallampati classification system. It would appear the favoured tool as all of the included studies have measured the Mallampati class. It has been suggested that there is a correlation between oropharyngeal structure exposure on mouth opening and laryngeal exposure during direct laryngoscopy. Certain patient characteristics are assessed pre-operatively that have been known to be associated with, or potentially with,

difficult intubation. The aim is to be able to anticipate a difficult airway and plan accordingly for the morbidly obese. A failed intubation can be considered a mere annoyance or manifest into serious patient compromise and even death (Samsoon & Young, 1987).

In the Mallampati et al (1985) study a discovery revealed that the visibility of the pharyngeal structures and direct laryngoscopy views were linked. This revolutionised pre-operative assessment and how the results were managed. They went on to conclude that the ability to visualize the pharyngeal structures was linked to difficulty with intubation. The lower the Mallampati class (more structures seen) the easier the laryngoscopy and intubation would be (Mallampati et al., 1985).

Juvin et al (2003) and Hekiert et al (2007) are in agreeance that the Mallampati class is an independent predictor for difficult intubation. Juvin et al (2003) claim that higher Mallampati classes (III or IV) are independent risk factors for difficult intubation in obese patients, whereas the BMI was not. The Hekiert et al (2007) study supports the work of Juvin and colleagues (2003). They deemed that the Mallampati class, when compared with the Cormack Lehane score, was a significant independent predictor of difficult laryngeal exposure during direct laryngoscopy. The significance of this result is difficult to interpret though, as half of the study subjects' Cormack Lehane grades were missing. In the smaller group, the remaining subjects with complete results proved the statement was statistically

significant. The question begs though, would the same result have been reproduced if they had had Cormack Lehane grades from all the participating subjects (Hekiart et al, 2007).

In the presence of an increased BMI, a high Mallampati class of III or IV was more likely to occur, than in lean patients. Voyagis et al (1998) found a correlation between BMI and the Mallampati class. This revealed that the greater the BMI the higher the Mallampati class might be. They contend that a BMI >30 contributes to difficult intubation. Voyagis et al (1998) demonstrated a correlation between BMI and the oropharyngeal classing. An obese patient with a high BMI was more likely to have poor visibility of pharyngeal structures leading to a potentially difficult intubation scenario. This suggests caution should be used in patients with a high BMI as the likelihood of a difficult intubation is increased.

Overall more obese patients had higher Mallampati classes than their lean counterparts (Combes et al., 2005; Hekiart et al., 2003). Brodsky et al (2002) and Voyagis et al (1998) all claim that the Mallampati scoring over-predicts when compared to the Cormack Lehane grades found upon direct laryngoscopy. Over prediction of Mallampati classes can cause unnecessary worry by the intubator. However, this author believes the over prediction should be acknowledged but not a reason to discount the Mallampati class from practice.

Overall, Mallampati is a helpful tool for predicting potential airway problems which allows for the health care team to plan for care of the morbidly obese appropriately. Additional planning and preparation that might ensue from a false positive is negligible given its low incidence. The risk/benefit ratio for using the tool would demonstrate the benefit is greater than the risk. This author doesn't believe there is a risk to the morbidly obese patient by using this tool.

There are certain patient characteristics that have been linked with potentially difficult laryngoscopy and intubation by the research studies. Impaired neck mobility and an overbite of teeth have been associated with an increased Cormack Lehane grade signalling a difficult intubation (Mallampati et al., 1985). Voyagis et al (1998) contends that a BMI >30 contributes to difficult intubation as does the presence of macroglossia.

Neck size is one patient characteristic that is frequently cited in the literature as a risk factor for potentially difficult intubation. Some studies (Brodsky et al., 2002; Hekiert et al., 2007) have demonstrated strong association between problematic intubations and neck circumference. Obese patients have a higher neck circumference when compared to lean patients. A high Mallampati class and large neck circumference have been associated with problematic intubations (Brodsky et al., 2002; Hekiert et al., 2007) and BMI and weight in both genders have been linked (Hekiert et al., 2007). Larger neck circumferences in men were specifically associated with high Mallampati class, Cormack Lehane grade III and obstructive



sleep apnoea (Brodsky et al, 2002). Large neck circumference is linked to higher Mallampati and Cormack scores increasing the possibility of a difficult intubation in men. If the pre-operative predictive tools and patient characteristic assessment suggest a difficult airway in a morbidly obese patient they advise an elective awake intubation should be considered (Voyagis et al, 1998).

It would appear that the Mallampati classification is useful as a predictor of a potentially difficult intubation and classes have been linked with the Cormack Lehane grades. In practice, knowledge of the over predictive component should be known but proves to be low in incidence so unlikely to impact on clinical practice greatly. A high Mallampati score in the obese and morbidly obese is associated with a high Cormack Lehane grade. Difficult intubation is linked with the patient characteristics of an increasing BMI, large neck circumference, neck mobility, possibly a history of sleep apnoea and maybe macroglossia. It would appear that obstructive sleep apnoea might play a role in difficult intubation. Therefore, questions surrounding snoring and obstructive sleep apnoea may be helpful in determining any difficulties with intubation and/or bag mask ventilation. The second theme to be explored is that pertaining to oxygenation and positioning of the morbidly obese patient in relation to endotracheal intubation.

## *Oxygenation and positioning*

The second theme identified from the research studies was that of oxygenation and patient positioning in relation to tracheal intubation in the morbidly obese. Maintaining adequate oxygenation during tracheal intubation can be challenging if the intubation is difficult or time consuming. Sedation and muscle relaxants cease spontaneous respiration to facilitate tracheal intubation. There is a period of apnoea involved while intubation takes place and then manual ventilation is commenced. Oxygen saturation values can drop during this time and the aim is to keep them at a safe level.

Juvin et al (2003) claim that oxygen tension values at the end of pre-oxygenation can be achieved equally in both lean and morbidly obese patients. Dixon et al (2005) determined that 3 minutes of pre-oxygenation in severely obese subjects in the 25 degrees head up position achieves a 23% higher oxygen tension. This allows a clinically significant increase in the time it takes for oxygen saturation values to fall. By using the 25 degrees head up position with morbidly obese patients, it takes longer for the oxygen saturation to fall to an unsafe level. The clinical application is that it provides a greater safety margin for intubation and airway control. Various positions for the morbidly obese have been explored such as the zero, 45 and 90 degree positioning. Altermatt et al (2005) agree with Dixon et al (2005). They tested pre-oxygenation in the sitting up position and found that oxygen saturation values took longer to reach an unsafe level in the morbidly obese by doing so. Position did not affect PaO<sub>2</sub>, PCO<sub>2</sub>, A-a gradient or

PaO<sub>2</sub>/FiO<sub>2</sub> ratio when comparing supine and sitting up position (Altermann et al, 2005).

Prior to intubating, bag-mask ventilation may be required or used after a failed intubation attempt. In some patients it can be difficult to bag mask ventilate and again, prior knowledge of this can be of assistance to the health care team. Langeron et al (2000) identified five risk factors that were significantly associated with difficult mask ventilation (DMV): age >55 years, BMI >26, edentulous, beard and a history of snoring. Beards can interfere with good mask seal onto the face and snoring appears again highlighting the need for a thorough history and assessment pre-intubation.

The reverse Trendelenburg at 45 degrees affords a greater tidal volume, lower respiratory rate and is the preferred position according to morbidly obese patients, (Burns, et al., 1994). Boyce et al (2003) declares that the reverse Trendelenburg position is superior and affords a greater safety margin during apnoea, followed by the back up Fowler position. Morbidly obese patients placed in the reverse Trendelenburg position recover from falls in the oxygen saturation values twice as quickly as those in the back up Fowler position. The supine position is not advised for the morbidly obese as falls in the oxygen saturation values occur much faster and take twice as long to recover from (Boyce et al, 2003).

Positioning for the morbidly obese in preparation for endotracheal intubation is different to lean patients. The head elevated laryngoscopy position is recommended to facilitate airway management in the morbidly obese. This position is known as the ramped position which raises the patients head and neck above the chest and abdomen. By using a ramped position, lower Cormack-Lehane grades are achieved making this position superior to the traditional sniff position for direct laryngoscopy in the morbidly obese population (Collins et al., 2004). Adoption of this position will enhance the laryngoscopic view and improve the success of intubation. The ramped position is achieved by placing blankets under the upper part of the body to align the sternum to the external auditory meatus along a horizontal plane (Collins et al., 2004).

Juvin et al (2003) and Dixon et al (2005) agree that morbidly obese patients experience lower oxygen saturation values than lean patients during intubation. Interestingly, the time taken to intubate was not recorded in the Juvin et al study. It may have helped explain the morbidly obese groups' minimum oxygen saturation value. It may have been solely related to the altered respiratory physiology or could the morbidly obese group have had longer intubation times which contributed to their lower oxygen saturation values? Dixon et al (2005) confirm that morbidly obese patients do in fact drop their oxygen saturation values very fast.

In the supine position, oxygen saturation values fall quickly and take longer to recover to normal values for the morbidly obese. Improved pre-oxygenation and extended time for oxygen values to fall can be achieved in the head up 25 degrees

or back up Fowler position. Morbidly obese patients have greater tidal volumes and lower respiratory rates in the reverse Trendelenburg position. Patients have indicated that they favour the reverse Trendelenburg position. Morbidly obese patients should be placed in a ramped position for endotracheal intubation which will assist in the providing the greatest laryngeal exposure. DMV can occur in practice and anticipating this assists the planning and preparation for the intubation. There are five patient characteristics that are associated with DMV; age >55 years, BMI >26, edentulous, beard and a history of snoring. In the presence of two or more of these high risk characteristics would indicate a high likelihood of DMV occurring.

### *Endotracheal intubation*

The third theme identified from the research studies is endotracheal intubation in relation to morbidly obese patients. The perception is that morbidly obese patients are more difficult to intubate than lean patients. By employing good positioning to optimise laryngeal exposure and optimising oxygenation endotracheal intubation can be easier than it would otherwise be.

Difficult intubation, not laryngoscopy is more frequent in morbidly obese patients. Difficult laryngoscopy defined as Cormack Lehane grade III or IV is similar between morbidly obese and lean patients (Juvin et al., 2003). A BMI >30 contributes to a difficult intubation. Morbid obesity and moderate obesity demonstrate the same risk for difficult intubation. This suggests that once someone reaches moderate

obesity the risk for difficult intubation will not increase even if their BMI does (Voyagis et al., 1998).

Langeron et al (2000) identified difficult ventilation-difficult intubation and difficult ventilation-impossible intubation scenarios had an incidence of 1.5% in their study involving 1502 patients. Although this is a low incidence, a plan is still required for when it does occur. Rescue devices can be made readily available for the anticipated difficult airway. When there is a high suspicion of or known difficult airway, an awake fiberoptic intubation should be considered. Awake fiberoptic intubation involves topical anaesthesia of the oral cavity and the vocal cords, psychological preparation for the patient and sometimes light sedation that does not impede spontaneous respiration. The endotracheal tube is passed with fiberoptic guidance visualising the trachea (El-Sohl., 2004; Lavery & McClosky., 2008). Morbidly obese patients with high Cormack-Lehane grades should be considered for an awake fiberoptic intubation (El-Sohl, 2004).

A combined difficult intubation and a Cormack Lehane grade of three and four occurred significantly more often in patients who demonstrated difficult mask ventilation (DMV) (Langeron et al., 2000). The presence of DMV indicates that the patient could be a potentially difficult intubation. Obese and morbidly obese patients often have higher rates of difficult views on laryngoscopy. The degree of laryngeal exposure correlated to the BMI, each increasing in tandem (Hekiart et al., 2007). This would indicate that as BMI increases so will the Cormack Lehane

grade signifying poor laryngeal exposure. In this instance, difficult intubation would be more likely. It is important to remember that not all obese patients are difficult intubations at all. Mallampati et al (1985) explains that in his study the four obese patients having a gastroplasty for obesity were all easy laryngeal views and intubations (Mallampati et al, 1985).

When an artificial airway has been established it is recommended by general consensus that tidal volumes are set at ideal body weight and peak airway pressures are limited to 35cm H<sub>2</sub>O. Excessive peak airway pressures would cause alveolar distention and eventually barotrauma if tidal volumes were calculated on actual body weight (El-Sohl, 2004). Positive end expiratory pressure set at 10 cm H<sub>2</sub>O to the intubated and ventilated morbidly obese patient will improve lung volumes, oxygen and carbon dioxide tensions and elasticity (Pelosi et al., 1999).

Patients with DMV are at a greater risk for a high Cormack Lehane grade and difficult intubation. Impossible to ventilate situations do occur and a plan should be made for that. The degree of laryngeal exposure does relate to BMI. An increasing BMI would indicate an increase in the Cormack Lehane grade. The risk for difficult intubation does not increase once obesity is present. Severity of obesity does not appear to increase the risk of difficult intubation. The only difference noted is between those with obesity and those without. The final theme identified is airway management with a rescue device.

### *Airway management rescue device: intubating laryngeal mask airway*

The final theme identified within the research studies is airway management using the rescue device, the intubating laryngeal mask airway (ILMA). This is a rescue device that can be used when traditional intubation with an endotracheal tube has been unsuccessful in the morbidly obese.

Combes et al (2005) endorse the ILMA as a good choice for managing a morbidly obese airway. The ILMA is marginally more efficient and successful in obese patients than lean patients. Samsoon and Young (1987) explain the success of the ILMA in morbidly obese patients is due to the fat deposits around the face and airway providing better contouring with the ILMA. Ventilating through the LMA component is achieved with a better seal before the endotracheal tube is passed through the ILMA. Combes et al (2005) explain that obese patients had less failed blind intubations with the ILMA than the lean patients. Safe use of the ILMA was demonstrated equally in each group, obese and lean (Coombes et al., 2005). There was no difference found between experienced and un-experienced operators of the ILMA insertions (Frappier et al., 2003). This suggests it is a relatively straightforward device to use that could be of great assistance for a more junior person attempting intubation..

Frappier et al (2003) states that possibly higher Cormack Lehane grades may lead to slightly longer intubation times with the ILMA in morbidly obese rather than lean patients. Morbidly obese are already more likely to have higher Cormack Lehane



grades so this could be a problem for this population. It means that it will be important to optimise positioning and pre-oxygenation to slow any drops in oxygen saturation values that might occur during a longer intubation time.

Combes et al (2005) highlighted that the mean minimum arterial oxygen saturation during airway management was comparative between the obese and lean patients, (96% Vs 98% respectively).

The ILMA proves to be an effective and safe rescue device that can be used by people intubating with varying experience. Oxygenation during intubation with the ILMA in morbidly obese patients is comparative to that of lean patients. The success rate of endotracheal intubation with the ILMA was essentially equal between groups, although the morbidly obese group demonstrated a slightly higher success rate overall. There is concern that intubation with an ILMA takes slightly longer. If intubation has already failed then there is more benefit to using it as it is often effective in morbidly obese patients. Oxygenation can be improved significantly with bed head elevation pre-oxygenation that will slow the fall of oxygen saturation values if it does occur. This buys time to manage the airway and gain control without a serious fall in oxygen saturation values.

## *Body Mass Index and its limitations*

The BMI appears to be the most common measure of obesity in the studies reviewed. It is a widely accepted measure to determine obesity. The BMI is familiar to many and simple to apply to subjects. Although it is used by all the studies in this review, it is important to highlight that BMI has limitations when applying the study findings to practice.

Patients in the ICU could be misclassified related to total body fat content and therefore could miscalculate the risk of difficult intubation. Muscle distribution, bone density, body shape and ethnic factors can impact on the BMI. For example a muscular athlete could have a BMI that classifies him as overweight when clearly there is no excess fat. This can be explained by muscle weighing more than fat. The BMI often misclassifies the shortest and tallest people as obese which are another group of people that demonstrate a limitation in the standard BMI table. The WHO developed a classification table for BMI ranges based on mortality outcomes where confounding variables such as cigarette smoking and existing comorbidities were controlled for (WHO, 2000). In practice, knowledge of the BMI limitations need to be considered before making clinical decisions using the results. With regards to tracheal intubation it would appear appropriate to include neck circumference in decision making processes when considering potential difficult intubations.

### *Other measures of obesity*

The BMI is not the only measure available to measure obesity. Waist circumference is a useful measurement for abdominal obesity which can add value to the BMI result. Visceral fat is important and may not be detected with an obese BMI score in some ethnicities. Excessive abdominal fat is an independent risk factor for some diseases and disorders, more so than total body fat (Ministry of Health, 2008a; WHO, 2000). Waist measurements can be very difficult to achieve in the ICU. Possibly the emergency department could do waist measurements on admission to hospital or in the ward.

Abdominal obesity is a significant issue that has serious health implications. The New Zealand Cardiac Rehabilitation guideline (2002) suggests measuring waist circumference when BMI's reach thirty-five. There are no ethnic variations to this recommendation. Regardless of ethnic origin, the literature indicates that health risks can exist in lower BMI's due to fat distribution and ethnicity. It would appear that measurements of BMI and waist circumference should be done jointly to encompass all risk factors. It could be argued that the New Zealand Cardiac Rehabilitation guideline (2002) is adding the waist circumference too late, when disease has probably already manifested. Data extracted from an Australian diabetes study (1999-2000) revealed that 27% of men and 34% of women aged 25 years and over were abdominally obese (Australian Institute of Health & Welfare, 2008). Those statistics are significant as the risk to health for more than a quarter of Australians is tremendous. The New Zealand lifestyle is not too dissimilar to that of Australia.

There are proposed ideal waist circumference measurements to strive for, to ensure a reduced risk of disease they are; men <92cm and women <80cm in Europeans. Again, ethnic variations of acceptable measurements need to be considered (WHO, 2000).

In New Zealand the waist circumference ranges alter slightly from the WHO recommendations in 2000. The reason for this is not evident. It could be hypothesized that the WHO have taken a harder line with their recommendations. The lower cut offs may induce people classed as overweight to re-evaluate their health and lifestyle practices. The New Zealand table includes proposed ethnic variations in the measurements (refer Table 9). The ethnic variations are interesting to compare as there is no difference between European and Maori and Pacific Islanders, particularly since Pacific Islanders have a larger bone structure overall. The deviation from the WHO guidelines that have lower cut off margins is interesting. There is another obesity measurement that can be employed which is

Table 9: Proposed waist circumference measures in different adult ethnic groups

	Men	Women
New Zealand European	< 102cm	< 88 cm
Pacific Islands and Maori People	< 102 cm	< 88 cm
Asian and Indian People	< 90 cm	< 80 cm

From: NZ cardiac rehabilitation guideline, (2002). Appendix: Assessment of overweight and obesity. Retrieved on 27/01/10 from [http://www.nzgg.org.nz/guidelines/0001/Assessment\\_Overweight.pdf](http://www.nzgg.org.nz/guidelines/0001/Assessment_Overweight.pdf)

the waist-to-hip ratio (WHR). Historically, the WHR was considered more informative than the waist circumference in isolation. Currently, recent evidence has revealed that the WHR does not compliment the waist circumference significantly to warrant its use. In particular it is more challenging and complicated to undertake (Ministry of Health, 2008a).

The BMI is the most common tool used to measure obesity within the literature. To strengthen results further, a waist circumference measurement can compliment BMI findings.

## **IMPLICATIONS OF THE SYSTEMATIC REVIEW**

### *Limitations of the systematic review*

The author would like to acknowledge some limitations that have been identified in relation to this systematic literature review. Letters to the editor and review articles were excluded. By doing so, it is possible some valuable information may have been missed such as, something not proven yet in a study but is expert opinion based on observations of patient responses in practice. There are many specialised equipment and procedures for intubation that were not discussed that could be used or undertaken in the morbidly obese i.e.; gum elastic bougie, standard LMA, combitube, emergency cricothyroidotomy, awake fibre-optic intubations.

Some of the information might be slightly diluted as there were several main themes and information could have been more concentrated if only one theme was discussed. The greatest limitation to this review was that the data was not all specific to morbidly obese patients and obese data was extrapolated in some instances. It is not known about the specific differences between obese and morbidly obese. One study did identify there was no greater risk for difficult intubation for the morbidly obese than the moderately obese, demonstrating equivalence (Voyagis et al., 1998). Impacting on the data analysis was the variety of classifications the studies used to define obese and morbidly obese.

### *Implications of findings for practice*

The findings of this systematic literature review have implications for nurses and nursing practice. The findings of this systematic literature review can be developed into practice guidelines for ICU nurses. This will guide intensive care nursing practice when planning to intubate morbidly obese patients. The new knowledge surrounding endotracheal intubation for the morbidly obese can be included in the ICU orientation programme and ICU specific study days. This knowledge is vital to ensure preparedness and promote safety when intubating morbidly obese patients, particularly when the intubation is emergent in nature.

ICU nurses will be able to identify potentially difficult airways using predictive tools and patient characteristics for clinical decision making. Nurses will be able to perform techniques that will optimise oxygenation. Pre-intubation oxygen tension will be increased due to nurses starting pre-oxygenation with the bag-mask on 15 litres per minute in the ramped position. This allows the doctor and other nurse's time to prepare for the intubation. Optimal pre-oxygenation can be achieved and not delay intubation, in fact it will be catalysed.

Nurses will understand the rationale for advocating the ramped position for intubation of the morbidly obese patient, promoting evidenced based practice. Appropriate resources can be employed early such as blankets or pillows for positioning. Nurses can proactively have the rescue device ILMA accessible, as they will possess knowledge of its application to the morbidly obese during

endotracheal intubation. Knowledge of other airway adjuncts for the morbidly obese will promote patient safety. Importantly it will eliminate or limit cardio-respiratory complications associated with intubation and the effects of the altered respiratory physiology demonstrated in morbid obesity.

The results of this systematic literature review can be developed into practice guidelines and taught in educational settings in the ICU demonstrating evidenced based practice. This new knowledge provides the ability to anticipate potentially difficult airways and the necessary specialty resources and techniques to support endotracheal intubation.

### *Implications of findings for research*

There are implications of the findings for future research. Research for the morbidly obese should be done on morbidly obese patients only, using the WHO classification system, to truly reflect the morbidly obese population. Possible constraints for this are the low incidence of morbid obesity when compared with the general population. It could take a protracted length of time to have sufficient study participants to ascertain reliability and validity.

Many of the research studies used obese and morbidly obese patients interchangeably. It is not clear, however, that obesity and morbid obesity are interchangeable with regards to endotracheal intubation. Are there differing factors that affect endotracheal intubation between the obese and morbidly obese population?



More detailed research is needed to compare intubation between these two subgroups of obesity. That would demonstrate whether obese findings can be extrapolated with certainty to the morbidly obese population.

## CONCLUSION

Airway management in morbidly obese patients needs adequate planning and preparation. Ensuring proper patient positioning prior to induction of anaesthesia is essential to avoid potential dangers. The ramped position has been endorsed as providing a better view during direct laryngoscopy (Collins et al., 2004). Pre-oxygenation in the ramped position achieves 23% higher oxygen tension, allowing clinically significant increases in the time it takes for oxygen saturations to fall to unsafe values and greater time for intubation and airway control (Dixon et al., 2005).

The Mallampati classification system is probably the most reliable predictive tool for identifying a potentially difficult intubation and correlates with the Cormack Lehane grades. Interestingly, El-Sohl (2004) believes that a high BMI is not associated with problematic intubation in the morbidly obese. Instead, a large neck circumference and a Mallampati score of three or more significantly correlated with a high probability of problematic intubation. These findings are reflected in the current literature (Brodsky et al., 2002; Hekiert et al., 2007; Voyagis et al., 1998). Certain patient characteristics are associated with difficult intubations such as; an increased BMI, reduced neck mobility, macroglossia and a large neck circumference can all present problems during intubation, particularly if paired with a high Mallampati classification. It is suggested that obstructive sleep apnoea and snoring may also play a role in the degree of risk for the morbidly obese.

The reverse Trendelenburg position is used to limit the push of abdominal contents on the diaphragm facilitating greater lung excursion. This position provides better respiration and enhanced patient comfort during intubation and for ongoing care (Burns et al., 1994).

There are several factors that influence endotracheal intubation in the critically ill morbidly obese patient in the intensive care unit. This systematic literature review will contribute to evidenced based practice and the development of practice guidelines to ensure safe and efficient care is promoted and delivered for the morbidly obese within intensive care settings.

## **RECOMMENDATIONS**

In practice, there needs to be a guide for BMI differences between ethnicities. The traditional BMI is based on Europeans and are not using different ethnicities i.e. Asians are possibly falling through the loop as Asian obesity is defined by a BMI >26 and in practice recognized as obese by a traditional BMI > 30. This could be too late for Asians who may already have developed a co-morbidity like diabetes.

The systematic literature review suggests that neck circumference is a more appropriate measure of difficult intubation than BMI. A guide for practice should include large neck circumference as a patient characteristic used to identify potentially difficult intubations rather than BMI which is a less reliable predictor.

No New Zealand research studies were found during the literature search for this research question. This suggests that there is an opportunity for some New Zealand research to be undertaken and could include varying ethnicities i.e.; Maori, Pacific Islanders, Europeans and Asians in the study. A New Zealand perspective would be invaluable in guiding our practice here in New Zealand and to identify any differences.

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## GLOSSARY

**A-a gradient** is the difference of the oxygen pressure in the alveolar spaces and arterial blood (the free dictionary by Farley)

**Barotrauma** is damage to the lung from rapid or excessive pressure changes, as may occur when a patient is on a ventilator and is subjected to high airway pressure (MedicineNet.com)

**Cardiac index** is derived from the cardiac output which is the amount of blood the left ventricle ejects into the systemic circulation in a minute measured in litres/minute. Then the cardiac output is indexed to a patient's body size by dividing by the body surface area to calculate the cardiac index (MedicineNet.com).

**Chandy maneuver** is when the ILMA is rotated slightly along the sagittal plane while bagging until the least resistance is felt. This helps to align the internal aperture of the ILMA up with the glottic opening to aid blind endotracheal intubation (Ferson, Rosenblatt, Johansen, Osborn & Ovassapian, 2001).

**Cormack-Lehane Grading** is a scoring system used during direct laryngoscopy to assess the degree of laryngeal exposure seen. It has four grades (1-4) and higher grades are associated with more difficult intubations. Knowing the grade can be useful information for subsequent intubations. If an airway is known to be difficult, additional planning can be done for future intubations to maintain safety and avoid complications (MedicineNet.Com).

**DLE** is difficult laryngeal exposure upon direct laryngoscopy (Hekiert, Mick & Mirza., 2002).

**DMV** is difficult mask ventilation (Langeron et al., 2000).

**DSP** is the desaturation safety period. After three minutes of pre-oxygenation, the ventilation is stopped and the time taken for Sao2 to fall to 92% is measured and recorded as the DSP (Dixon et al., 2005).

**Endotracheal intubation** is when a flexible plastic tube is passed through the mouth down into the trachea (windpipe) and can be ventilated via the endotracheal tube (MedicineNet.com).

**Fibreoptic intubation** a fibreoptic scope is preloaded with an endotracheal tube and then passed through the trachea when visualised (Crown & Singh, 2004).

**Functional residual capacity** is the volume of gas remaining in the lung after a normal expiration, mainly determined by the balance between the elastic recoil of the chest and lung (Pelosi et al., 1999).

**Gum elastic bougie** is a thin rubber cylinder that is inserted into the trachea and used to guide an endotracheal tube into place in the trachea. (MedicineNet.com)

**Intubating laryngeal mask airway** is a tube with a rounded rubber end that sits opposing the larynx and fills the hypopharynx. Then using a stylet, the flexible endotracheal tube is passed through the laryngeal mask into the trachea, completing intubation (Crown & Singh, 2004).

**Laryngoscope** is a lighted instrument that is placed into the mouth to view the larynx to assist with intubation (medicineNet.com).



**Laryngoscopy** is the examination of the larynx with the laryngoscope (medicineNet.com).

**Mallampati score** is a preoperative scoring system that involves assessing the open mouth for the degree of visibility of the pharyngeal structures. It is probably the most reliable predictor of intubation success. The modified version involves class I-IV. As the score gets higher, the likelihood of a potentially difficult airway increases (Crown & Singh, 2004).

**Oxygen saturation** is the concentration of oxygen in the blood represented as a percentage. (MedicineNet.com)

**PaO<sub>2</sub>/FiO<sub>2</sub> ratio** is the ratio of arterial oxygen tension to inspired fraction of oxygen which is a widely used clinical index of hypoxaemia (Whiteley, Gavaghan & Hahn, 2002).

**Positive end expiratory pressure** is a component of ventilation in which airway pressure is maintained at the end of expiration to keep gas in the lungs to stop alveolar from collapsing completely at end expiration. The aim is to improve oxygenation and prevent blood shunting to the lungs. (MedicineNet.com)

**SAP** is the safe apnoea period. Patients are preoxygenated, then ventilation is stopped and the time taken for Sao<sub>2</sub> of 100% to fall to 92% is the SAP.

**Sternomental distance** is measured from the sternum to the tip of the mandible with the head extended. A distance of 12.5cm or less predicts a difficult intubation (Wilson & Kopf, 1998).

**Thyromental distance** is a measurement made from the thyroid notch to the lower margin of the mandible with the neck extended. Measured by fingers, less than three fingers indicates possible difficulties with viewing the larynx on direct laryngoscopy (Crown & Singh, 2004).

**VAS** is visual analog score. The score grades laryngeal exposure upon direct laryngoscopy (1-10) with a score of >3 considered difficult (Hekiert, Mick & Mirza., 2007).

## APPENDIX

### Appendix One - CASP TOOL: Cohort studies

#### CRITICAL APPRAISAL SKILLS PROGRAMME making sense of evidence

#### 12 questions to help you make sense of a cohort study

##### *General comments*

- Three broad issues need to be considered when appraising a cohort study.

*Are the results of the study valid?*

*What are the results?*

*Will the results help locally?*

The 12 questions on the following pages are designed to help you think about these issues systematically.

- The first two questions are screening questions and can be answered quickly. If the answer to those two is "yes", it is worth proceeding with the remaining questions.
- There is a fair degree of overlap between several of the questions.
- You are asked to record a "yes", "no" or "can't tell" to most of the questions.
- A number of italicised hints are given after each question. These are designed to remind you why the question is important. There will not be time in the small groups to answer them all in detail!

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# A/ Are the results of the study valid?

## Screening Questions

<p><b>1 Did the study address a clearly focused issue?</b></p> <p><i>HINT: A question can be focused in terms of:</i></p> <ul style="list-style-type: none"><li>- the population studied</li><li>- the risk factors studied</li><li>- the outcomes considered</li><li>- is it clear whether the study tried to detect a beneficial or harmful effect?</li></ul>	<p>Yes Can't tell No</p> <p>— — —</p>
<p><b>2 Did the authors use an appropriate method to answer their question?</b></p> <p><i>HINT: Consider</i></p> <ul style="list-style-type: none"><li>- Is a cohort study a good way of answering the question under the circumstances?</li><li>-Did it address the study question?</li></ul>	<p>Yes Can't tell No</p> <p>— — —</p>

***Is it worth continuing?***

**Detailed Questions**

<p><b>3 Was the cohort recruited in an acceptable way?</b></p> <p><i>HINT: We are looking for selection bias which might compromise the generalisability of the findings:</i></p> <ul style="list-style-type: none"> <li>- Was the cohort representative of a defined population?</li> <li>- Was there something special about the cohort?</li> <li>- Was everybody included who should have been included?</li> </ul>	<p align="center"><b>Yes Can't tell No</b></p> <p align="center">— — —</p>
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<p align="center"><b>4. Was the exposure accurately measured to minimize bias?</b></p> <p><i>HINT: We are looking for measurement or classification bias:</i></p> <ul style="list-style-type: none"> <li>- Did they use subjective or objective measurements?</li> <li>- Do the measures truly reflect what you want them to (have they been validated)?</li> <li>- Were all the subjects classified into exposure groups using the same procedure?</li> </ul>	<p align="center"><b>Yes Can't tell No</b></p> <p align="center">— — —</p>
	<p align="center"><b>Yes Can't tell No</b></p>

<p style="text-align: center;"><b>5. Was the outcome accurately measured to minimize bias?</b></p> <p><i>HINT: We are looking for measurement or classification bias:</i></p> <ul style="list-style-type: none"> <li>- Did they use subjective or objective measurements?</li> <li>- Do the measures truly reflect what you want them to (have they been validated)?</li> <li>- Has a reliable <u>system</u> been established for detecting all the cases (for measuring disease occurrence)?</li> <li>- Were the measurement methods similar in the different groups?</li> <li>- Were the subjects and/or the outcome assessor blinded to exposure (does this matter)?</li> </ul>	<p style="text-align: center;">_ _ _</p>
<p><b>6. A. Have the authors identified all important confounding factors?</b></p> <p>List the ones you think might be important, that the authors missed.</p> <p><b>B. Have they taken account of the confounding factors in the design and/or analysis?</b></p> <p><i>HINT:</i></p> <ul style="list-style-type: none"> <li>- Look for restriction in design, and techniques eg</li> </ul>	<p><b>Yes Can't tell No</b></p> <p style="text-align: center;">_ _ _</p> <p><b>Yes Can't tell No</b> _ _ _</p> <p><b>List:</b></p>

<p><i>modelling, stratified-, regression-, or sensitivity analysis to correct, control or adjust for confounding factors</i></p>	
<p><b>7. A. Was the follow up of subjects complete enough?</b></p> <p><b>B. Was the follow up of subjects long enough?</b></p> <p><i>HINT:</i></p> <ul style="list-style-type: none"> <li>- <i>The good or bad effects should have had long enough to reveal themselves</i></li> <li>- <i>The persons that are lost to follow-up may have different outcomes than those available for assessment</i></li> <li>- <i>In an open or dynamic cohort, was there anything special about the outcome of the people leaving, or the exposure of the people entering the cohort?</i></li> </ul>	<p>Yes Can't tell No __ __ __</p> <p>Yes Can't tell No __ __ __</p>

**B/ What are the results?**

<p><b>8. What are the results of this study?</b></p> <p><i>HINT:</i></p> <ul style="list-style-type: none"> <li>- <i>What are the bottom line results?</i></li> <li>- <i>Have they reported the rate or the proportion between the exposed/unexposed, the ratio/the rate difference?</i></li> <li>- <i>How strong is the association between exposure and outcome (RR,)?</i></li> </ul>	<p><b>9. How precise are the results?</b></p> <p><b>How precise is the estimate of the risk?</b></p> <p><i>HINT:</i></p> <ul style="list-style-type: none"> <li>- <i>Size of the confidence intervals</i></li> </ul>
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<p>- What is the absolute risk reduction (ARR)?</p>	
<p><b>10. Do you believe the results?</b></p> <p><i>HINT:</i></p> <ul style="list-style-type: none"> <li>- Big effect is hard to ignore!</li> <li>- Can it be due to bias, chance or confounding?</li> <li>- Are the design and methods of this study sufficiently flawed to make the results unreliable?</li> <li>- Consider Bradford Hills criteria (eg time sequence, dose-response gradient, biological plausibility, consistency).</li> </ul>	<p><b>Yes Can't tell No</b></p> <p>— — —</p>

***Is it worth continuing?***

<p><b>C/ Will the results help me locally?</b></p> <p><b>11. Can the results be applied to the local population?</b></p> <p><i>HINT: Consider whether</i></p> <ul style="list-style-type: none"> <li>- The subjects covered in the study could be sufficiently different from your population to cause concern.</li> <li>- Your local setting is likely to differ much from that of the study</li> <li>- Can you quantify the local benefits</li> </ul>	<p><b>Yes Can't tell No</b></p> <p>— — —</p>
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<i>and harms?</i>	
<b>12. Do the results of this study fit with other available evidence?</b>	<b>Yes Can't tell No</b>  — — —