THE OBESE PATIENT:

ANAESTHETIC ISSUES (AIRWAY & POSITIONING)

AND SOLUTIONS

Bale EJ
Berrecloth RJ
January 2010

1. INTRODUCTION

The standard classification of bodyweight according to the Body Mass Index is described in the table below(1):

BMI	Class	BMI	Class
< 20	Underweight	35-49.9 + co- morbidity	Morbidly Obese
20-24.9	Normal	50-59.9	Super obese
25-29.9	Overweight	60-69.9	Super super obese
30-39.9	Obese	>70	Hyper obese
40-49.9	Morbidly obese		

Current statistics from the Department of Health reports show a trend which accurately predicts 22% of men and 23% of women to be obese in 2010. If no action is taken this equates to 60% of men, 50% of women and 25% of children being obese by 2050(2).

It is unanimously agreed that obesity is an increasing problem in the populations of all developed and, increasingly, developing countries. It is also accepted that this sector of the population present specific challenges when required to undergo general anaesthesia. 'As a result of the obesity epidemic, anesthetists are more commonly confronted with the challenge of anesthetizing severely obese patients. The technical challenges and risks in obese individuals are appreciably higher than those of healthy weight individuals.' Dixon et al(3)

What is not so evident is a universal approach to assessing, predicting and overcoming these challenges. Furthermore, in the authors' experience, where there is the presentation of a clearly high risk patient, there can be limitations in optimizing the environment for a variety of reasons: in order to save time, a lack of resources or sheer apathy on the part of the theatre staff.

2. ANATOMY & PHYSIOLOGY: IMPLICATIONS AND ASSOCIATED RISKS

Morphologically patients fall into two broad categories: android and gynaecoid. In the android the fat is carried mainly in the trunk: they have a fat face and cheeks, large breasts, a short, large neck with an associated restricted cervical spine and atlanto-occipital flexion and extension; they tend to carry abdominal fat intraperitoneal. The respiratory tract might include a large tongue, excessive palatal and pharyngeal soft tissue and high anterior larynx. These factors alone, many feel, could indicate difficult mask ventilation and tracheal intubation with the incidence of difficult intubation at 13%. With the gynaecoid patient, the fat is mainly in the arms, legs and buttocks with the abdominal fat mainly extraperitoneal. The problem for clinicians is that many patients will lie somewhere in the spectrum between these two groups and require individual assessment(1) (5).

Although attitudes are changing it is still occasionally heard that obese patients are thought to be 'fine because they have more padding,' when in fact the opposite is true. The sheer force of the weight on their trunk and limbs during surgery compresses the intervening tissues against the table or attachments and can compromise perfusion. (External pressures of 23-32mm/Hg can interfere with normal tissue perfusion and, in patients with peripheral vascular disease, tissue damage can occur at even lower pressures(7)). The results are two-fold: poor arterial capillary perfusion can result in ischaemia and poor venous return can result in oedema thus raising pressures within the tissues further. Furthermore as the byproducts of continued local cell metabolism are not removed due to ineffective circulation, osmosis causes even further oedema and local tissue pressure. The result of this is pressure sores, with accompanying breakdown in tissue leading, untreated, to necrosis(7). It has been stated that patient perception is that pressures sores are preventable and directly attributable to poor nursing care which raises the spectre of litigation(8).

As well as pressure sores, neural injuries are more common in high and very high BMI patients especially if they are diabetic(5). Babatunde et al describe the risks comprehensively, ‘Brachial plexus and sciatic nerve palsies have been reported. Stretch injuries may be caused by extreme abduction of the arms, thereby stretching the lower roots of the brachial plexus. The upper roots are most likely stretched by excessive rotation of the head to the opposite side. Sciatic nerve palsy may be caused by prolonged ischemic pressure from tilting the table sideways. Lateral femoral cutaneous nerve injury may occur if the lower limb falls and hangs freely(14)(15). Ulnar neuropathy has been associated with increased BMI. A retrospective study by Warner et al (13) documented such an association because 29% of patients with ulnar neuropathy in their series had a BMI equal to >38 compared with 1% of control patients.’(9)

Physiologically many factors contribute to put high BMI patients’ pulmonary and cardiovascular systems under strain. Obese patents have an increased oxygen consumption and carbon dioxide production due to their increased metabolic activity(5). They have reduced functional residual capacity (FRC) associated with reduced lung compliance as a result of an increase in pulmonary blood volume. It is also affected by the reduction in chest wall compliance due to the fat within the wall. Combining these restrictions with the fat within the abdomen, FRC is further reduced and airway resistance increased by mechanical compression of the diaphragm and lungs(5).

Positioning an obese patient in the supine position for induction exacerbates these complications as described by Brodsky, ‘Supine obese patients have relative hypoxemia and significant alterations in the mechanical properties of their respiratory system because of marked reductions in lung volume. In the supine position, intra-abdominal pressure is increased, causing a splinting effect of abdominal contents on the diaphragm. The supine obese patient has a proportionally greater decrease in FRC, total respiratory system and pulmonary compliance, and a larger ventilation/perfusion (V/Q) mismatch than normal weight patients. These changes increase with increasing BMI.’(22)

‘Some morbidly obese patients cannot tolerate the supine position. In a study of cardiovascular changes in obese patients scheduled for gastric stapling surgery, changing from the sitting to supine position caused significant increases in O2 consumption, cardiac output and pulmonary artery pressure. By lying down, a decrease in already poor chest wall compliance, further V/Q mismatch, and a sudden shift of blood to an already hyperactive, borderline hypoxic heart occurred. For some obese patients with inadequate cardiac reserve, these changes can lead to fatal cardio-respiratory decompensation, termed *Obesity Supine Death Syndrome*.’(4)

FRC is shown to fall by 50% in the supine obese patient on induction in comparison to 20% in the normal population. This has been shown to decrease the effectiveness of preoxygenation and tolerance to any period of apnoea. ‘Combining the effect of reduced pulmonary compliance with upper airway obstruction, the clinician can expect more difficulty with face mask ventilation.’(5) (6)

3. ASSESSMENT

Within the population of high BMI patients the key question of who are likely to present critical problems during induction and intubation is much debated. The criteria used to indicate potential problems vary from paper to paper. For example some will cite obstructive sleep apnoea (OSA) amongst other co-morbidities usually associated with difficult intubation as an indicator of airway difficulties (5) where others claim it has no significance(10).

Others simply cite a high BMI per se (with or without pregnancy) as being an indicator of difficult intubation(3) (5) (6) (11) (12), while others dispute this(16).

It is fair to say that the debate between the correlation of obesity and difficult intubation arises for two reasons Firstly there seems to be the lack of an objective definition of difficult intubation. Adnet et al validated an objective scoring system, Difficult Intubation Score (DIS) comprised of giving a point per variable that deviated from the optimum: i.e. number of attempts, number of additional clinicians, number of alternative techniques, glottis exposure Cormack & Lehane definition, lifting force applied during laryngoscopy, need for cricoid pressure, position of vocal cords at intubation; such that a score of 0 would represent intubation achieved at first attempt by one clinician using one technique with minimal force and full view. A score over 5 could be classed as difficult intubation(10). This was used by Juvin et al in their study to ascertain factors to predict difficult intubation in obese patients but could only conclude that Mallampati of III or IV was a risk factor. They added however that it had questionable value in clinical practice due to its lower sensitivity, specificity and negative predictive value with obese patients. They felt jaw mobility limited by fat was more pertinent. Moreover BMI was not a predictor; the higher the BMI does not mean the greater the difficult intubation(10).

The usual five variables to predict intubation difficulty: Modified Mallampati, range of head and neck motion, width of mouth opening, presence of overbite, presence of mandibular recession, abnormalities eg tumours, and co-morbidities eg OSA were not found to be reliable indicators of difficult intubation(10).

The second reason a dispute arises is because some studies that showed a positive correlation between obesity and difficult intubation and those that showed no correlation were of questionable methodology. For example they did not use a control group, used a small number of patients or failed to distinguish between difficult intubation and difficult laryngoscopy(10).

Based on the findings of the literature available it seems that the most reliable indicator of potential difficult intubation is neck circumference(10) (16) (23). Brodsky et al found in a population of 100 patients 12 presented difficulty with intubation, with only high Mallampati scores and neck circumference shown to be reliable predictors of problematic intubation. He cites the chance of encountering problems with intubation is about 5% with a neck circumference of 40cm and 35% with a neck circumference of 60cm. NB All the patients were ramped(16).

Gonzalez et al also confirmed that intubation was more difficult in the obese patient but that neck circumference and Mallampati >3 were the most reliable predicting factors(23).

4. SOLUTIONS

It has been noted that, where no difference in intubating obese patients has been found, this seems to have been due to the use of 'ramping' the patient so that the head and shoulders are considerably raised(17). The results of Rao et al were so positive that they state, 'on the basis of our results we propose that positioning patients in the head-elevated position by elevating the back or trunk section of the table can be considered by clinicians as part of their pre-formulated strategy in their daily clinical practice in managing the airways of obese patients.'(17)

Cattano et al reinforce that great care should be taken to ensure that the head and neck is ramped up to establish a patent airway(11).

One method of evaluating laryngeal view is via the Percentage Of Glottal Opening Score. Lee et al found that it improved significantly in the 25 degree back-up position compared with supine. 'Direct laryngoscopy depends upon the forward flexion of the cervical spine and the extension of the head at the atlanto-occipital joint to align the oral, pharyngeal and laryngeal axes.' Their study of 40 patients showed that, if difficult intubation is associated with poor visibility of the larynx, then the 25% improvement in the view in the 25 degree head up position may be significant in how clinicians approach potentially difficult intubations.(18).

Collins et al studied 60 morbidly obese patients to compare sniff position with ramped position. 'The result was that the ramped position improved laryngeal view when compared to a standard sniff position and this difference was statistically significant (P=0.037) which leads to the conclusion that the ramped position is superior to the standard 'sniff' position for direct laryngoscopy in morbidly obese patients.'(19)

The study by Dixon et al also showed preoxygenation to be more effective in the 25 degree head up position(3).

Brodsky et al (4) (16) refer frequently to the importance ramping the patient so that, 'An imaginary horizontal line should connect the patient's sternal notch with the external auditory meatus.'(21) See *figures 1* and *2*. 'The Head Elevated Laryngoscopy Position (HELP) significantly improves the view during direct laryngoscopy.'(22) they emphasize that the head and trunk must be elevated. Their intubation success rate was 99% compared with a similar rate of 97% demonstrated in the Keller study however in this study 15% required a bougie and only 33% had a grade 1 Cormack view. In the Brodsky et al study no one was reported to need a bougie and 75% had a grade 1 view. It was implied that this discrepancy was due to the patients in the Keller study being raised up by only 8 cm(21).

Figure 1 Misaligned anatomy

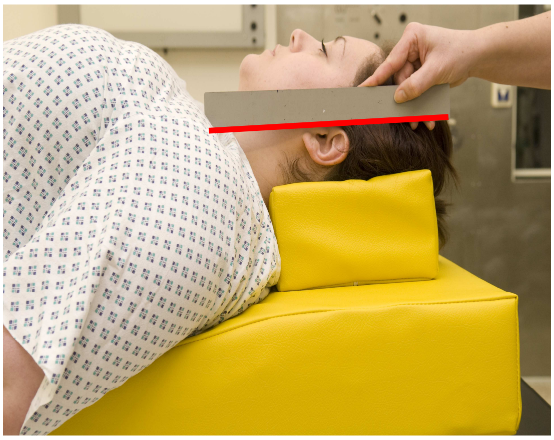

Figure 2 Realigned anatomy

Brodsky makes the pertinent point that in the normal population head-up positions can have a potentially negative haemodynamic effect if venous return to the heart is reduced, with any beneficial effects on oxygenation being offset if cardiac output is decreased. However, he adds that no adverse cardiovascular changes were noted in a study of morbidly obese patients placed in the reverse Trendelenburg's position(20). Furthermore in a study of normal BMI patients induced at a 20 degree angle none needed intervention for hypotension(24).

The head elevated position also has implications from an ergonomic point of view. It has been reported as being more comfortable for the clinician; "he did not need to lower his head or bend his back or his knees to see the larynx because the visual field was improved and the optimal position of the clinician's eye was moved upward."(18)

5. HOW THE RAMPING TECHNIQUE IS ACHIEVED

There are various methods used by clinicians to achieve the ramping effect of positioning a high BMI patient. One method is to use a stack of linen and pillows as shown in *figure 3* and while this does effectively align the sternal notch with the external auditory meatus it is inadequate in other ways: The overall effect is inelegant and shambolic and clearly has no scientific means of ensuring the required degree of elevation. Secondly it is notoriously difficult in operating departments to get hold of surplus linen and pillows which would then all have to be put into the laundry for washing at the end of the procedure which is a waste of resources. Thirdly, and probably reflective of the former point, there is no support for the arms thereby risking neural damage to the brachial plexus through stretching. Fourthly if for any reason the patient had to be laid supine post intubation it would be very cumbersome to remove the stack and would undoubtedly put strain on attending members of staff and the patient(25). Finally there is bound to be some rucking up of the linen as the patient was positioned which predisposes her to pressure sores.

Figure 3 Patient ramped on blankets and pillows

The other problem with the stacking method as more clearly demonstrated in *figure 4* is that the patient frequently ends up with too much neck flexion which can inhibit face mask ventilation as well as making laryngoscopy more difficult. Moreover restricted access to the neck makes cricoid pressure more difficult to achieve.

The other point to mention about the positioning of patients like that in *figure 4* is that laryngoscopy is only likely to be more comfortable from the clinician's point of view if they are sufficiently tall. If the clinician is of medium or short stature then they will require a standing stool and will have to lean over which is going to put stress on their back. This is an increasingly relevant point as many anaesthetists are female and from regions where people are of shorter stature for example Asia.

Rao SL, Kunselman AR, Schuler HG, DesHarnais S. Laryngoscopy and tracheal intubation in the head elevated position in obese patients: a randomized, controlled, equivalence trial. *Anesthesia & Analgesia* 2008; 107:1912-8 Reproduced with permission

Figure 4

The patient position illustrated in *figure 4* is achieved on electrically controlled equipment. The authors of *Anaesthesia for the Overweight and Obese Patient* reported that automated equipment has failed due to sheer weight of the patient(1).

Other clinicians have proposed using a stack of three litre irrigation bags but similar problems arise as with the linen. They are also heavy to manoeuvre as well as there being clear issues regarding the stability of the patient. Irrigation bags would not have product liability indemnity if they are used as patient support devices.

There are also inflatable devices used to achieve the ramp effect however the brachial plexus is still not supported and it is not clear that these devices are powerful enough to withstand the pressure of hyper obesity. Further research needs to be done in this area.

So far the most effective method of achieving the head elevated laryngoscopy position is by using a pre-manufactured device as described by Rich, '(it) eases the work of breathing for those patients who cannot lay flat secondary to obesity-induced orthopnea. Therefore, the patient is better able to tolerate the pre-induction period or longer period of time when required.' 'The elevation pillow can be prepositioned inserted and removed much faster and with less difficulty than that required to build and dismantle a ramp made of hospital linen.'(27)

There are a number of such pillows on the market. One in particular is a component of the Oxford HELP (Head Elevating Laryngoscopy Pillow), a unique bariatric system(30). This system is comprised of ten components. *Figure 5* shows the basic system including a ramped base pillow and headrest. Unlike other products of this design the HELP does not incorporate *Velcro* so that the headrest can be easily moved to accommodate the head falling back into a sniffing the morning air position where laryngoscopy and cricoid manipulation are easily simultaneously achieved. *Figure 7*

Figure 5 Oxford HELP

Figure 6 Patient on the HELP

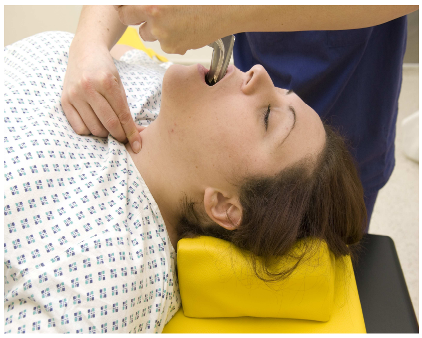

Figure 7 Cricoid manipulation

The angle of ramping has been shown to facilitate easy face mask ventilation in patients of BMI of 50 by senior and junior staff. Specifically, a very petite SHO at a bariatric centre used the device on a patient with a BMI of 56 and found the induction to be no more stressful than that of a patient with a normal range BMI. Her response was 'why don't we do this with every patient?' We would advocate using this product particularly in areas where inexperienced staff are likely to come across high BMI patients perhaps out of hours or in remote clinical areas(28).

The perceived benefit by the patient is that they can breathe much more easily in the semi-recumbent position than when lying flat and this feeling of well-being reduces anxiety and oxygen consumption during induction.

The system also comes with an upper pillow (*figure 8*) which is generally recommended for patients in the super to hyper obese range and has been proven to be effective with a patient of BMI 81.2.

Figure 8 Oxford HELP with the Oxford HELP Plus

The system comes with a BMI chart (29) (*figure 9*) specifically designed for high BMI patients. It provides a guide to help clinicians choose the right components for their specific patient although as discussed above, fat distribution can vary enormously between patients of similar BMIs so clinicians must use their professional judgement.

H (cm)	Oxford Head Elevating Laryngoscopy Pillow BMI Obesity Guide																							H (ft)
2.01	15	17	20	22	25	27	30	32	35	37	40	42	45	47	50	52	54	57	59	62	64	67	69	6'7"
1.98	15	18	20	23	26	28	31	33	36	38	41	43	46	48	51	54	56	59	61	64	66	69	71	6'6"
1.95	16	18	21	24	26	29	32	34	37	39	42	45	47	50	53	55	58	60	63	66	68	71	74	6'5"
1.93	16	19	21	24	27	30	32	35	38	40	43	46	48	51	54	56	59	62	64	67	70	72	75	6'4"
1.91	16	19	22	25	27	30	33	36	38	41	44	47	49	52	55	58	60	63	66	69	71	74	77	6'3"
1.88	17	20	23	25	28	31	34	37	40	42	45	48	51	54	57	59	62	65	68	71	74	76	79	6'2"
1.85	18	20	23	26	29	32	35	38	41	44	47	50	53	56	58	61	64	67	70	73	76	79	82	6'1"
1.83	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	6'0"
1.81	18	21	24	27	31	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79	82	85	5'11"
1.78	19	22	25	28	32	35	38	41	44	47	50	54	57	60	63	66	69	73	76	79	82	85	88	5'10"
1.75	20	23	26	29	33	36	39	42	46	49	52	56	59	62	65	69	72	75	78	82	85	88	91	5'9"
1.73	20	23	27	30	33	37	40	43	47	50	53	57	60	63	67	70	74	77	80	84	87	90	94	5'8"
1.70	21	24	28	31	35	38	42	45	48	52	55	59	62	66	69	73	76	80	83	87	90	93	97	5'7"
1.67	22	25	29	32	36	39	43	47	50	54	57	61	65	68	72	75	79	82	86	90	93	97	100	5'6"
1.65	22	26	29	33	37	40	44	48	51	55	59	62	66	70	73	77	81	84	88	92	96	99	103	5'5"
1.62	23	27	30	34	38	42	46	50	53	57	61	65	69	72	76	80	84	88	91	95	99	103	107	5'4"
1.60	23	27	31	35	39	43	47	51	55	59	63	66	70	74	78	82	86	90	94	98	102	105	109	5'3"
1.57	24	28	32	37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	97	101	105	110	114	5'2"
1.55	25	29	33	37	42	46	50	54	58	62	67	71	75	79	83	87	92	96	100	104	108	112	117	5'1"
1.52	26	30	35	39	43	48	52	56	61	65	69	74	78	82	87	91	95	100	104	108	113	117	121	5'0"
1.49	27	32	36	41	45	50	54	59	63	68	72	77	81	86	90	95	99	104	108	113	117	122	126	4'11"
1.48	27	32	37	41	46	50	55	59	64	68	73	78	82	87	91	96	100	105	110	114	119	123	128	4'10"
W (kg)	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	W (kg)
W (st)	9.5	11.0	12.6	14.1	15.7	17.3	18.9	20.4	22.0	23.6	25.1	26.7	28.3	29.9	31.4	33.0	34.6	36.1	37.7	39.3	40.9	42.4	44.0	W (st)
W (lb)	133	154	176	198	220	242	264	286	308	330	352	374	396	418	440	462	484	506	528	550	572	594	616	W (lb)

YOUR NEAREST OXFORD H.E.L.P. IS LOCATED: email: info@almamedical.com

Figure 9 Oxford HELP BMI Obesity Guide

The associated problems of pressure sores (9) and neuropathy have been discussed at length and we concur with Brodsky in his caveat, 'Patient position during surgery is extremely important. Pressure points must be carefully padded to reduce the risk of pressure sores, neurologic injury, and rhabdomyolysis (RML)(22).

In the authors' clinical experience, as controversial as it might be, issues surrounding potentially injurious episodes such as limbs becoming displaced from the operating table can be overlooked by medical and non-medical staff alike in their patient follow-up. Similarly post-operative aches and pains can sometimes be dismissed as simply the toll of being in the same position for a number of hours. While this can be true we have made great efforts to ensure that, with our system, every possible eventuality can at least be addressed using practical methodology. In this respect the Oxford HELP system makes a unique contribution to reducing the inherent risks by providing ancillary support devices as featured in *figure 10* and explained below.

This image shows the patient on the Oxford HELP and Oxford HELP Plus. She has the Oxford Cuneo supporting posterior to her scapula, the Arm Supports and Arm Supports Plus take the weight of her arms and the Oxford Sinus gives support posterior to her knee

Figure 10
©2010 Alma Medical Products

The Oxford HELP Arm Supports (*figure 11*) are designed to fit on existing operating table arm boards as well as having straps to retain the patient's arms. These reduce the risk of stretch injury to the brachial plexus. The Arm Support also provides a firm base on which to rest the arm if cannulation is being performed in the patient's bed.

Figure 11 Oxford HELP Arm Supports
© 2010 Alma Medical Products

Figure 12 Oxford HELP Arm Supports Plus
© 2010 Alma Medical Products

If the patient is further elevated then the Arm Support Plus (*figure 12*) might have to be placed on top of the Arm Supports. If the patient has to be recovered on a trolley, these extra pads are also useful for lateral protection from the bars.

The Oxford Cuneo (*figure 13*) is a triangular shaped wedge that can be used as posterior support to the scapula if there is a 'buffalo' ridge of fat between the shoulder blades. This can be found in the very high BMI patients and prevents the shoulders from being supported when the patient is lying on a flat surface. The Cuneo is also a useful aid for extending the wrist during radial arterial line insertion.

Figure 13 Oxford Cuneo

Figure 14 Oxford Sinus

The Oxford Sinus (*figure 14*) is a semi-cylindrical device designed to give support posterior to the knees in very high BMI patients who have large posterior pads of fat on their thighs and calves thus predisposing their knees to hyperextend when in a semi-recumbent position.

The Oxford HELP is very stable once the patient is positioned; there is no slippage as *figures 15 and 16* demonstrate.

Figure 15 Trendelenburg at 20˚

Figure 16 Left tilt at 15˚

NB: Obese patients are inherently unstable; we recommend that all patients are strapped to the operating table as per hospital policy and extreme vigilance is exercised whenever a patient is moved on the device or tilted at any angle(30).

The system is robust yet lightweight with the basic pillow and headrest weighing just 2.4 kilos. It is versatile enough to be used in many clinical areas from obstetric to bariatric anaesthesia, recovery and procedures under sedation. It is safe, hypoallergenic, withstands multiple uses, easy to clean and provides a complete solution to the challenges discussed in this article.

References

1 Bellamy M, Struys M. *Anaesthesia for the overweight and obese patient* OUP 2007; 3
2 Zaninotto P, Wardle H, Stamatakis E, Mindell J, Head J. *Forecasting Obesity to 2010* 2006 DOH website.
3 Dixon BJ, Dixon JB, Carden JR, Burn AJ, et al. Preoxygenation is more effective in the 25 degree head-up position than in the supine position in severely obese patients: a randomized controlled study. *Anesthesiology* 2005; 102:1110-5
4 Brodsky JB. Positioning the morbidly obese patient for anesthesia. *Obesity surgery* 2002; 12:751-758
5 Adams JP, Murphy PG. Obesity in anaesthesia and intensive care. *Br J Anaesth* 2000; 85:91-108

6 Altermatt FR, Munoz HR, Delfino AE, Cortinez LI. Pre-oxygenation in the obese patient: effects of position on tolerance to apnoea. *Br J of Anaes* 2005; 95(5):706-709
7 Beckett AE. Are we doing enough to prevent patient injury caused by positioning for surgery *Journal of Perioperative Practice* 2010; 20:26-29
8 Dimond B. Pressure ulcers and litigation. *Nursing Times* 2003; 99 (5):61
9 Babatunde OO, Jones SB, Jones DB, et al. Anesthetic considerations for bariatric surgery. *Anesth Analg* 2002; 95:1793-1805
10 Juvin P, Lavaut E, Dupont H, et al. Difficult tracheal intubation is more common in obese than in lean patients. *Anesth Analg* 2003; 97:595-600
11 Cattano D, Melnikov V, Khalil Y, Sridhar S, et al. An evaluation of the rapid airway management positioned in obese patients undergoing gastric bypass or laparoscopic gastric banding surgery. *Obes surg* 2009; 10: 1007
12 Walls RM. Obesity does not make intubation difficult. *Journal Watch Emergency Medicine* 2002 May 29
13 Warner MA, Warner ME, Martin JT. Ulnar neuropathy: incidence, outcome and risk factors in sedated or anesthetized patients. *Anesthesiology* 1994; 81:1332-40
14 Jupiter JB, Ring D, Rosen H. The complications and difficulties of nonunion in the severely obese. *J Orthop Trauma* 1995; 9:363-70
15 Sawyer RJ, Richmond MN, Hickey JD, Jarratt JA. Peripheral nerve injuries associated with anaesthesia. *Anaesthesia* 2000; 55:80-91
16 Brodsky JB, Lemmens HJ, Brock-Utne JG, Vierra M, Saidman LJ. Morbid Obesity and tracheal intubation. *Anesth Analg* 2002; 94:732-6
17 Rao SL, Kunselman AR, Schuler HG, DesHarnais S. Laryngoscopy and tracheal intubation in the head elevated position in obese patients: a randomized, controlled, equivalence trial. *Anesth Analg* 2008; 107:1912-8
18 Lee BJ, Kang JM, Kim DO. Laryngeal exposure during laryngoscopy is better in the 25 degree back-up position than in the supine position. *Br Journal of Anaesthesia* 2007; 99(4):581-586
19 Collins JS, Lemmens HJ, Brodsky JB, Brock-Utne JG, et al. Laryngoscopy and morbid obesity: a comparison of the 'sniff' and 'ramped' positions. *Obes Surg*. 2004; Oct 14(9):1171-5
20 Perilli V, Sollazzi L, Bozza P, et al. The effects if the reverse Trendelenburg position on respiratory mechanics and blood gases in morbidly obese patients during bariatric surgery. *Anesth Analg* 2000; 91: 1520-5.
21 Brodsky JB, Lemmens HJ, Brock-Utne JG, Saidman LJ, Levitan R. Anesthetic considerations for bariatric surgery: proper positioning is important for laryngoscopy. *Anesth Analg* 2003; 96:1841-1842
22 Brodsky JB. *Anaesthesia, Pain, Intensive Care & Emergency APICE* Springer Milan 2008; 29:305-312
23 Gonzalez H, Minville V, Delanoue K, Mazerolles M, et al. The importance of increased neck circumference to intubation difficulties in obese patients. *Anesth Analg* 2008; 106:1132-1136
24 Lane S, Saunders D, Schofield A, Padmanabhan R, et al. A prospective, randomized controlled trial comparing the efficacy of pre-oxygenation in the 20 degree head-up vs supine position. *Anaesthesia* 2005; 60:1064-1067
25 Nissen MD, Gayes JM. An inflatable, multichambered upper body support for the placement of the obese patient in the head-elevated laryngoscopy position Anesth Analg 2007; 104:1305-1306
26 Wong AB, Moore MSR. Positioning of obese patients in out-of-operating room locations. *Anesth Analg* 2007; 104:1306
27 Rich JM. Use of an elevation pillow to produce the head-elevated laryngoscopy position for airway management in morbidly obese and large-framed patients. *Anesth Analg* 2004; 98:264-79.
28 Lewis G (editor) Why Mothers Die 2000-2002 London RCOG Press; 2004
29 *Alma Medical Products BMI Obesity Chart* © Alma Medical Products 2010
30 *Alma Medical Products Oxford HELP Instructions for use* © Alma Medical Products 2010