Bariatric Issues in General Anaesthesia relating to Airway (BIGAA): a prospective observational study of elective surgical patients

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Introduction

The United Kingdom is in the midst of an obesity crisis, with the percentage of individuals in England with a body mass index (BMI) $\geq$25kg.m^{-2} increasing from 52% in 1993 to 62% in 2016. Over the same time period, the obese population (BMI $\geq$30kg.m^{-2}) has increased from 15% to 26% [1]. Of the obese patients, the fastest growing subpopulation is those with class four obesity (BMI $\geq$40kg.m^{-2}), which is projected to rise from 3% in 2016 to 8% by 2035 [2]. Obesity is a risk factor for numerous comorbidities and contributed to 617,000 hospital admissions in England in 2016-2017, an 18% increase on 2015-2016 [1]. While the impact of increased obesity-related hospital admissions has upon operating lists is unknown, it is likely that obesity is disproportionately over-represented in the surgical population.

Obesity has effects on multiple organ systems relevant to the perioperative period. Patients with obesity are more likely to suffer from metabolic and cardiovascular disease, have poorer physiological reserve, have significantly altered lung mechanics and provide more challenging airway management. As a result, obesity is a risk factor for a myriad of adverse events during anaesthesia. The 4th national audit project (NAP4) found that obesity was over-represented 2-fold, and morbid obesity 4-fold, in major airway events [3]. A common theme in these reported cases was failure of anaesthetists to adapt their airway management in the context of obesity and decreased success of rescue techniques. NAP4 made 12 recommendations surrounding airway management in the obese – including recognition of the role that specialist equipment plays in these patients. The Association of Anaesthetists and the Society for Obesity and Bariatric Anaesthesia have also published a joint guideline making 16 recommendations surrounding perioperative management of obese patients [4]. In the aftermath of these publications, a 2016 survey looking at the extent at which NAP4 recommendations have been adopted found that nearly 90% of respondents worked in hospitals which did have specific equipment for managing airways in

the obese available [5]. However, the extent to which this equipment was used, and in what context, was not explored.

As NAP4 was concerned with significant airway events, it did not attempt to explore the prevalence of minor airway complications. However, it is estimated that for every major event, 720 minor airway events may occur [6]. While such complications, managed appropriately, are likely to be of little consequence, they may trigger a cascade of events leading to serious complication. Therefore, there is increasing emphasis on taking steps to maximise the likelihood of 'first-time success' in airway management. While previous studies have attempted to determine the prevalence of minor complications or looked at specific events in the context of obesity [7-9], none have explored how increasing BMI impacts the frequency and/or type of these events. Nor have studies determined what steps, if any, are taken to reduce the risk of their occurrence.

The aim of this study was to explore a number of aspects surrounding obesity in the perioperative period. This included determining what percentage of individuals undergoing elective surgery in England are obese, which to our knowledge has not been previously quantified. In addition to this, we wanted to assess what steps anaesthetists take during the perioperative period to mitigate anaesthetic risk and at what weight thresholds these steps are taken. We also wanted to assess what the incidence of airway complications, even minor, were and quantify how obesity impacted upon their incidence.

Methods

Study design, setting and participants

This prospective observational study of adult elective patients was carried out over two 24-hour periods between the 12th and 16th March 2018. This time period was chosen with the aim of achieving high rates of hospital-level capture (i.e. convenience), to produce data reflective of overall practice rather than just that of a cohort of participating clinicians.

Ethical Approval was waived under NHS guidance. Hospitals in the greater London area were invited to participate via the Pan-London Perioperative Audit and Research Network (PLAN). Thirty-nine sites were enrolled, and the study was coordinated by PLAN. Each hospital obtained approval from their local clinical governance department. No patient identifiable data was collected. The data collection periods were agreed locally.

The aim was to include all adult patients (> 18 years) undergoing elective surgery (as defined by the NCEPOD classification) requiring a general anaesthetic. Exclusion criteria included patients undergoing ophthalmic or obstetric surgery, or those undergoing general anaesthesia as rescue technique for failed regional or sedation.

Data Collection and Variables

All definitions were predefined. For each case included the following variables were collected: gender, age, height, weight and body shape. If the patient had obstructive sleep apnoea (suspected or diagnosed), home CPAP and the STOPBANG score. Grade of surgery as

defined by NCEPOD (minor, moderate, major, complex major) specialty was recorded, and cancer status. The induction location, patient position, pre oxygenation technique, use of airway adjuncts. The type of induction, airway device used, if an awake fibre-optic was performed. If intubation was performed, the device used, and number of attempts was recorded. The use of neuromuscular blockade, monitoring, reversal agent and depth of anaesthesia monitoring. Any airway problems and time of occurrence (induction or recovery) during the perioperative were recorded (desaturation to less 90%, failed mask ventilation, supraglottic airway device problem, aspiration, airway trauma, difficult intubation, cannot intubate cannot ventilate, oesophageal intubation, surgical airway and cardiac arrest.)

Data was collected for all patients in the anaesthetic room, theatre and recovery on a proforma. Hospital site investigators transcribed anonymised data for each patient into a secure web-based application (Redcap). Hospital sites were also required to submit how many total eligible cases were performed at their site on the day of collection, in order to determine capture rate. Data was subsequently analysed using the Tableau software package.

Results

A total of 2059 eligible patients underwent surgery during the study period, of which complete data sets were collected on 1874 anaesthetics. This represented a capture rate of 91%. The patients were distributed across 39 hospitals within the greater London area. This included 12 hospitals with a bariatric surgery service. 797 patients were male and 1077 female. The mean age was 52 years old and BMI 27.8kg.m^{-2}. 596 (31.8%) of patients were obese (BMI > 30kg.m^{-2}). Further patient demographics are summarised in table 1 and breakdown of weight classes in figure 1.

Table 1 Patient demographics

	Total	**Non-Obese (BMI <30) (%)**	**Obese (BMI >30) (%)**
Age (years)			
18 - 39	507	369 (72.8%)	138 (27.2%)
40 - 59	681	438 (64.3%)	243 (35.7%)
60 - 79	578	380 (65.7%)	198 (34.2%)
>80	108	90 (83.3%)	18 (16.7%)
Surgical specialty			
Bariatrics	13	0 (0.0%)	13 (100.0%)
Breast	94	62 (66.0%)	32 (34.0%)
Cardiac	44	28 (63.6%)	16 (36.4%)
ENT	174	126 (72.4%)	48 (27.6%)
General	353	231 (65.4%)	122 (34.6%)
Gynaecological	332	230 (69.3%)	102 (30.7%)
Maxillofacial	90	71 (78.9%)	19 (21.1%)
Neurosurgery	38	24 (63.2%)	14 (36.8%)
Orthopaedics	295	191 (64.7%)	104 (35.3%)
Plastics	62	45 (72.6%)	17 (27.4%)

Thoracics	39	32 (82.0%)	7 (18.0%)
Urology	295	205 (69.5%)	90 (30.5%)
Vascular	45	31 (68.9%)	14 (31.1%)
Surgical severity			
Minor	642	460 (71.6%)	182 (28.4%)
Moderate	769	524 (68.1%)	245 (31.9%)
Major	322	202 (62.7%)	120 (37.3%)
Major Complex	141	92 (65.2%)	49 (34.8%)

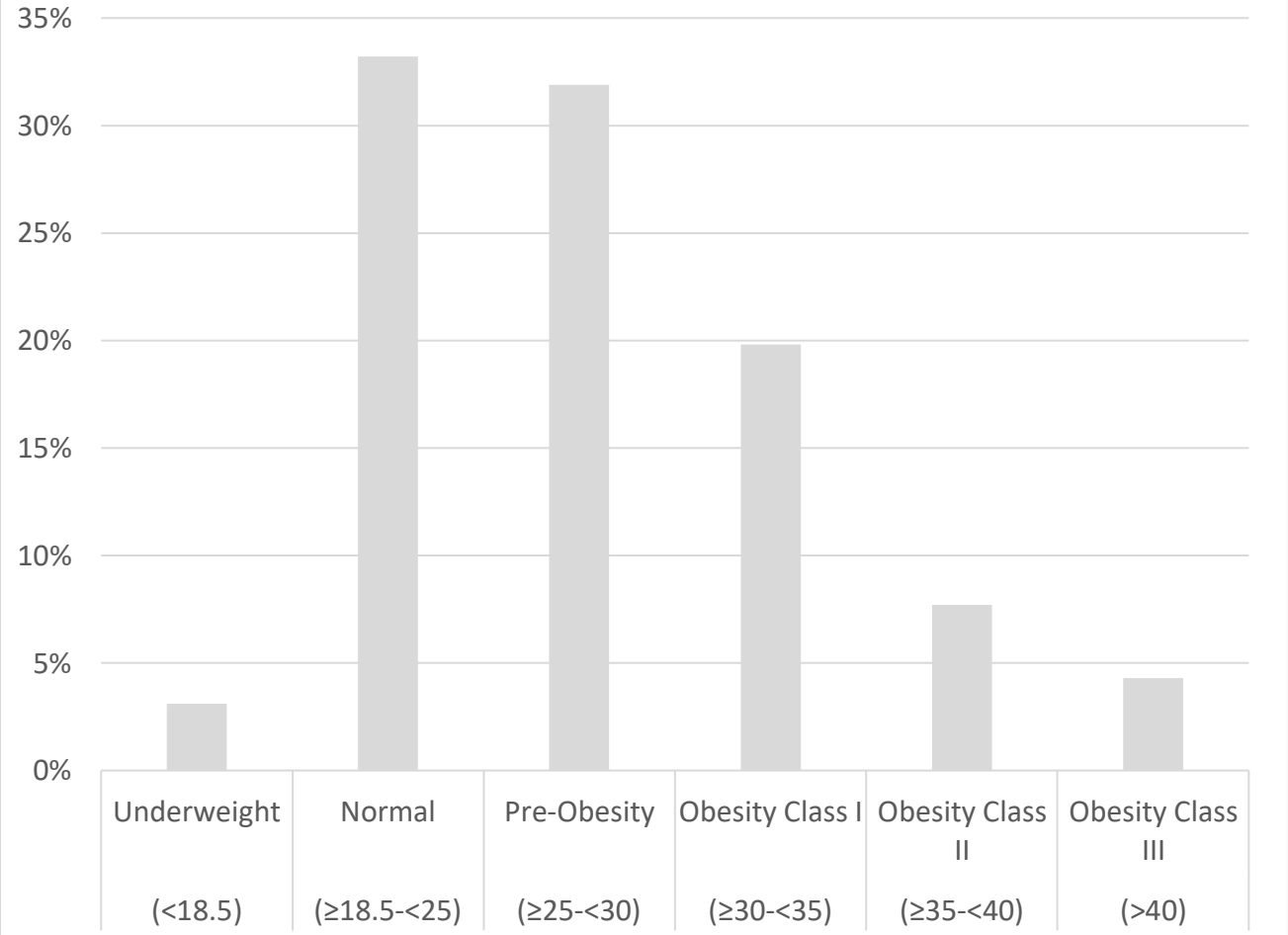

Fig. 1: BMI classes of study population (BMI values in $kg.m^{-2}$)

Primary Outcomes

There was a total of 91 airway-related events, an overall incidence 4.9%. The types of events are summarized in table 3. Overall, the event rate in obese patients was significantly higher than in non-obese. (RR 2.39, 95% CI 1.60-3.57) Event rates in obese patients increased with BMI: 5.7% in obesity class 1, 6.8% in obese class 2 and 21.3% in obesity class 3. The types of events affecting obese vs non-obese patients is summarized in tables 3, 4 and 5.

Table 3: Summary of airway incidents

Event:	Number (% of Events)
Airway Trauma	9 (9.9%)
Aspiration	1 (1.1%)
Desaturation (<90%)	35 (38.5%)
Difficult Intubation	16 (17.6%)
Failed bag-valve-mask ventilation	1 (1.1%)
Problem with SAD	23 (25.3%)
Oesophageal Intubation	2 (2.2%)
Re-intubated post-extubation	1 (1.1%)
Respiratory arrest	1 (1.1%)
Unplanned ICU admission due to airway	2 (2.2%)
Total	91 (100.0%)

Table 4: Problems at Induction and Perioperative Period

Problem Type	Obese patients affected (% of obese patients)	Non-obese patients affected (% of non-obese patients)	RR (95% CI)
Airway Trauma	3 (0.50%)	1 (0.08%)	6.43 (0.67-61.72)
Aspiration	1 (0.17%)	0 (0.00%)	6.42 (0.26-157.54)
Problem with SAD	12 (2.01%)	11 (0.86%)	2.33 (1.03-5.27)
Desaturation	11 (1.85%)	7 (0.55%)	3.36 (1.31-8.64)
Difficult intubation	5 (0.84%)	11 (0.86%)	0.97 (0.34-2.79)
Failed BVM	0 (0.00%)	1 (0.08%)	0.71 (0.02-17.50)
Oesophageal intubation	2 (0.34%)	0 (0.00%)	10.71 (0.51-222.78)

Table 5: Problems at Recovery

Problem Type	Obese patients affected (% of obese patients)	Non-obese patients affected (% of non-obese patients)	RR (95% CI)
Airway Trauma	2 (0.34%)	3 (0.23%)	1.42 (0.23-8.53)
Desaturation	13 (2.18%)	4 (0.31%)	6.97 (2.28-21.29)
Reintubation	0 (0.00%)	1 (0.08%)	0.71 (0.02-17.50)
Respiratory Arrest	0 (0.00%)	1 (0.08%)	0.71 (0.02-17.50)
Unplanned ITU	1 (0.17%)	1 (0.08%)	2.14 (0.13-34.22)

Association between incidence of airway-related event and use of obesity specific methods or equipment

Obese patients anaesthetised on the operating table had a significant reduction in intubation complications (n=4/111) compared to obese patients anaesthetised on a hospital bed (n=12/79). (RR 0.27, CI 0.09-0.81) There was no significant difference in intubation complications when comparing anaesthetising on the operating table to a hospital trolley (n=17/377). (RR 0.83, CI 0.28-2.43) The majority of obese patients were anaesthetised using a single pillow (80%). There was no significant difference in intubation complications between use of one pillow, two pillow and ramping patients. The Oxford-pillow was only used for eight anaesthetics in the entire study cohort.

Ninety-four percent of obese patients were pre-oxygenated prior to induction of anaesthesia. Trans-nasal Humified Rapid-Insufflation Ventilatory Exchange (THRIVE) was only used in 13 cases in the entire study cohort for pre-oxygenation.

Less than half (48%) of obese patients were intubated, intubation alone did not significantly reduce airway events compared to those managed using a SAD. (RR 0.90, CI 0.53-1.55) Intubation rates increased with obesity class (fig 2). The use of SAD in obese patients was associated with increased risk of airway events compared to using a SAD in non-obese patients (RR 3.46, CI 1.88-6.40). Airway events when using a SAD increased with BMI. 7.1% (n=14) of obesity class 1 managed with a SAD experienced an airway event , 7.8% (n=5) in obesity class 2 and 13.8% (n=4) in obesity class 3. 'Classic' SAD device use did not significantly decrease with increasing weight class. 22.6% of pre-obese patients ventilated via a SAD used a classic-SAD compared to 27.6% of class III patients. (Fig. 3) Supreme-LMA use did become more common with increasing weight class – 1.4% in pre-obese patients versus 6.9% in class III obesity.

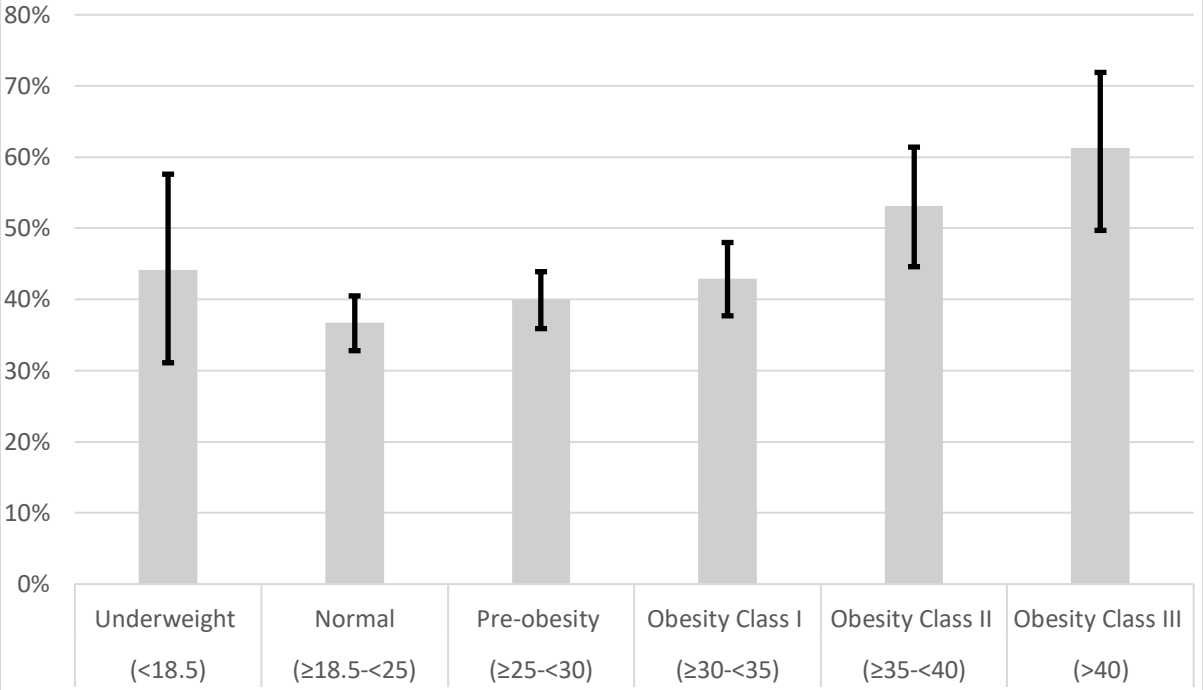

Fig 2: Intubation Rate (Error bars - 95% binomial CI) (BMI values in $kg.m^{-2}$)

Obese patients were significantly more likely to receive a neuromuscular blocking agent (NMBA) than non-obese. (RR 1.20, CI 1.08-1.34) However, obese patients were not significantly more likely to experience an airway event when NMBAs were used (n=25, 9.6%) compared to non-obese patients (n=31, 6.5%). (RR 1.43, CI 0.86-2.38) Of obese patients who received a NMBA, 47% (n=135) were monitored. The use of monitoring was not significantly protective against extubation complications in obese patients (n=5, 3.7% in monitored group versus n=5, 3.3% in unmonitored group). (RR 0.89, CI 0.26-3.02) Reversal was given to 67.8% (n=194) of obese patients who received NMBA. Of the obese patients given reversal, 46.4% (n=90) were given reversal without NMB monitoring being used. Use of reversal agent did not

significantly protect against complications during extubation (n=7, 3.6% in reversed group, 4.3% in un-reversed group. (RR 0.83, CI 0.25-2.77)

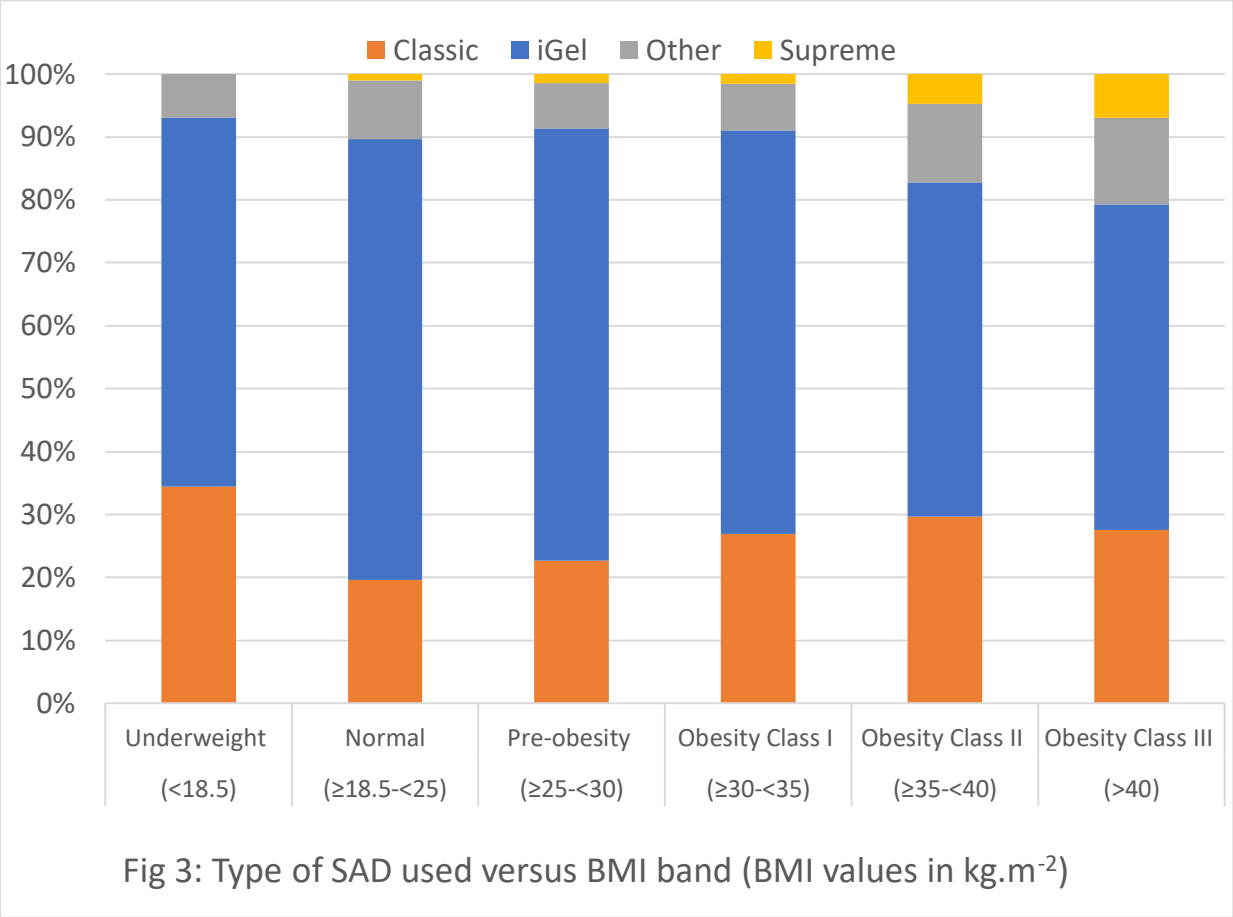

Fig 3: Type of SAD used versus BMI band (BMI values in $kg.m^{-2}$)

Videolaryngoscopy use increased with class of obesity, but overall use was low (fig 4). Failure rate of 1st attempt direct laryngoscopy varied between 8.6% and 12.7%, depending upon weight class, but there was no association between rising BMI groups and failure rates.

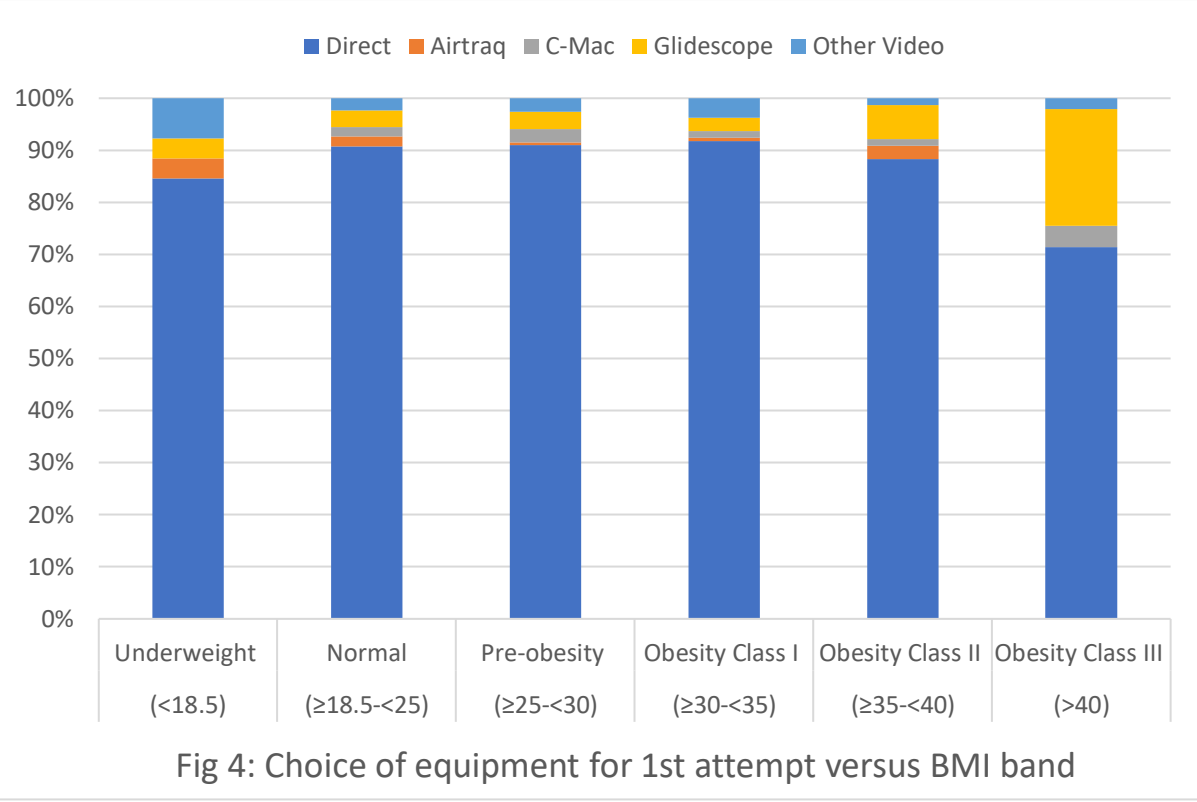

Fig 4: Choice of equipment for 1st attempt versus BMI band

Discussion

This study revealed that obesity is overrepresented in the elective surgical population compared to the general population (31.8% vs 26%). Airway related events were over twice as likely in obese patients – the most common being desaturation. Second most common was difficulty maintaining adequate ventilation using a SAD. SOBA guidelines regarding obesity stress the importance of preoxygenation and our data reinforces the prudence of this. Optimisation of preoxygenation position with an Oxford pillow was scarcely used, nor was THRIVE. The availability of equipment for THRIVE is likely contributory to this, but Oxford pillows are widely available yet seldom utilised. Anaesthetising in theatre for obese patients is a SOBA recommendation, and our findings support a reduced intubation complication rate when anaesthetising on the operating table compared to a hospital bed, but not hospital trolley. While overall numbers of complications were low so firm conclusions difficult to draw, the higher incidence of intubation problems with patients in beds may reflect the confounding effects of e.g. comorbidity burden. This warrants further research.

Obese patients were significantly more prone to desaturation on extubation. NMBA use was more common in obese patients, likely due to increased frequency of intubation, which has been known to contribute to this [11]. Neither the use of NMBA monitoring nor use of NMBA reversal offered significant protection against this outcome in our dataset. However, the common practice of administering NMBA reversal agents in the absence of NMBA monitoring suggests a group of obese patients with clinical suspicion of residual neuromuscular blockade which is not being quantified prior to extubation. The use of neuromuscular reversal in unquantified blockade goes against SOBA guidelines and given

that obese patients display altered pharmacokinetics of NMBAs [12], may leave patients at-risk of residual neuromuscular blockade.

Despite both NAP4 and SOBA guidelines advocating for a move away from 'classical' first-generation SADs, especially in those with obesity, their use remained widespread. Interestingly, classic SAD use increased with higher weight classes. Whether this is due to perception of improved performance of 'classic' SADs compared to second-generation devices or a matter of familiarity was not studied. Our study revealed that obese patients were significantly more likely to have issues with SADs and therefore careful selection of SAD-type is advised. While intubation rates did rise with weight class, we suspect SAD use was far more frequent than the "highly selected patients" which SOBA guidelines would recommend. Another aspect surrounding airway management in our study was the frequency of videolaryngoscopy use. Despite being the focus of a large amount of anaesthetic literature and conversation, only 8.2% of intubations in patients with class I obesity were performed using videolaryngoscopy, although this did increase to 28.6% in class III. However, despite an increasing body of evidence suggesting that videolaryngoscopy offers benefits over direct laryngoscopy [10], it still remains the far lesser used technique. The caveat to this is that difficult intubation remained rare, was not significantly increased in obese patients nor did grade of intubation view increase with severity of obesity, which is in-line with previous work [9].

The strengths of our study include prospective data collection and high capture rate of cases. Given this, we believe our data is representative of current airway management in elective surgical patients. While NAP4 highlighted major airway events, our study was more reflective of daily airway issues faced by anaesthetists. The reality of practice is that few anaesthetists will be confronted by major airway complications, however studies such as these maintain vigilance against slipping of standards in routine practice. In this context, our data is reassuring that even minor issues during elective airway management are infrequent. We believe further improvement is achievable and our work can inform future airway research in obese patients. It also highlights that obesity is a universal peri-operative challenge in our elective surgical population and adapting our techniques to reflect this is something we all must do.

Our study only focussed upon the elective surgical population as data capture in emergency areas (i.e. non-elective operating, intensive care and emergency departments) would likely be more challenging for numerous reasons. Many of these patients would not have an up-to-date height and weight, making the impact of obesity on airway management difficult to quantify. Obstetrics was excluded due to BMI being inapplicable to late pregnancy and the relative infrequency in which elective Caesarean sections are performed under general anaesthesia. Given that airway complications occur more frequently in non-elective and obstetric populations, both these groups would be of interest in future research.

Our dataset did not attempt to match obese versus non-obese patients based on comorbidities or primary pathology. While this would be desirable, the impact of such pathologies would not necessarily be clear in terms of its impact upon airway management, or the complications which may or may not result. It would also have significantly increased the burden of data collection on a local level, produced variability of data as opposed to our

fixed parameters and reduced the overall data quality. The 'snap-shot' nature of our study means on a local level certain case types and certain anaesthetic practices may have been excluded due to the nature of theatre scheduling across the week. Local data collection may therefore be similarly biased by the practice of a relatively small number of anaesthetists; however, we believe given the multi-centre nature of our study, our data is representative of overall practice.

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