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Original Article

Patient and surgery factors associated with the incidence of failed and difficult intubation

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Summary

Estimates of the rate and risk factors for difficult airway rarely include a denominator for the number of anaesthetics. Approaches such as self-reporting and crowd-sourcing of airway incidents may help identify specific lessons from clinical cases, but the lack of denominator data, biased reporting and underreporting does not allow a comprehensive population-based assessment. We used an established state-wide dataset to determine the incidence of failed and difficult intubations between 2015 and 2017 in Victoria, Australia, along with associated patient and surgical risk factors.

A total of 861,533 general anaesthesia cases were analysed. Of these, 4092 cases of difficult or failed intubation were identified; an incidence rate of 0.52% (2015–2016) and 0.43% (2016–2017). Difficult/failed intubations were most pronounced in patients aged 45–75 and decreased for older age groups, with risk being lower for patients aged 85 than patients aged 35–44. The risk for

failed/difficult intubation increased significantly for: patients undergoing emergency surgery (OR 1.80); obese patients (OR 2.48); increased ASA score; increased Charlson Comorbidity Index. Across all age groups, procedures on the nervous system (OR 1.92) and endocrine system (OR 2.03) had the highest risk of failed/difficult intubation.

The relative reduced risk for failed/difficult intubations in the elderly population is a novel finding that contrasts with previous research and may suggest a 'compression of morbidity' effect as a moderator. Administrative databases have the potential to improve understanding of peri-operative risk of rare events at a population level.

Introduction

Although anaesthesia is extremely safe, adverse events still occur, with complications related to airway management being those with the highest risk. The Fourth National Audit Project (NAP4) [1] demonstrated that, on average, one major airway complication occurs for every 22,000 general anaesthetics [2], with a mortality rate of one per 118,372 cases (0.0008%) [3]. While difficult or failed intubation occurs infrequently, 'can't intubate, can't ventilate' (CICO) situations are estimated to contribute to 25% of fatal events in anaesthesia [1].

Effective and reliable incident reporting systems remain a challenge in anaesthesia. Compared to other safety-critical industries such as aviation, incident reporting in healthcare is much less successful [4]. Incident reporting in anaesthesia is infrequent, incomplete [5, 6] and biased, seemingly occurring only reliably in systems where the purpose of collecting data is billing or administration [7]. Apart from a few exceptions such as the UK's national audit projects, data are skewed by collection from particular hospitals and by the voluntary nature of the reports. In addition, incident reporting in healthcare is often not anonymous, either because of the structure of the reporting system or because, at a local level word travels fast about unusual, difficult and rare, fatal cases. This lack of anonymity further lowers participation due to fears of shame, disciplinary or even legal action [8]. A means to continuously explore the incidence of airway management problems is warranted. Furthermore, if denominator data of the number of anaesthetics and the characteristics of the population could be determined, it would lead to a more comprehensive understanding of airway management at a population level.

National or state-wide databases may be of some use in addressing these deficiencies with current incident-reporting systems in anaesthesia. The Victorian Admitted Episodes Dataset (VAED) collects morbidity data on all admitted patients from hospitals in the state of Victoria, Australia. It provides comprehensive data on the causes and nature of illness or injury resulting in hospital admission. This also includes data on anaesthesia, including airway management complications such

as difficult and failed intubations. The purpose of the VAED is to assist with health service planning, research and hospital funding [9]. Data from the VAED has been utilised for research in critical care, for example to identify the impact of medical emergency response teams on mortality rates [10], the incidence and outcomes of tracheostomies [11] and injury mortality in general [12]. The VAED uses the 10th revision of the International Classification of Diseases and Related Health Problems (ICD-10) to code admitted care episodes. The difference between the VAED state-wide database and incident reporting systems is that the VAED collects all data related to patients' admitted hospital episodes and therefore provides comprehensive denominator data.

Using the VAED, we aimed to determine the incidence and risk factors for failed and difficult intubation during general anaesthesia in hospitals in the state of Victoria between 2015 and 2017. Recognised risk factors associated with the difficult and failed intubations were actively sought, including type of surgery, patient factors related to age, sex, comorbidities and the ASA physical status code. The secondary goal was to explore how the VAED data compares to existing incidence estimations on failed and difficult intubations and other reports from the same time period.

Methods

Ethics approval for this study using analysis of VAED data for injury surveillance purposes was obtained from the Monash University Human Research Ethics Committee. Data were extracted from the VAED for each admitted patient episode from all healthcare settings in the state of Victoria for the defined period. The VAED is coded according to the ICD-10-AM and since 2015 distinguishes between failed intubation (T88.41) and difficult intubation (T88.42) (see Table 1). Consequently, only data from 2015 onwards were included.

'Exposed' cases were selected from hospital admissions records from 2015/16 and 2016/17: relevant surgery cases using general anaesthesia (termed 'cerebral anaesthesia') were selected within the dataset, which is based on Australian Classification of Health Interventions (ACHI) coding. Within the relevant surgical cases, difficult and failed intubation cases were identified by inclusion of T88.4 codes. Obstetric-related codes for failed (O29.61; O74.71; O89.61) or difficult (O29.62; O74.72; O89.62) intubation were also included in the analysed data. By selecting surgical cases (general anaesthesia cases, 2716) only, difficult and failed intubation cases that may have occurred outside of a surgical setting (such as in the emergency department) were minimised. Cricothyroidotomy procedures were identified as cases with an ACHI procedure code 41884-00; these were considered likely to be emergency procedures that were carried out due to failure of airway management.

General anaesthesia cases with a documented ASA score of '9' indicating 'no documented ASA score' were also excluded, as these were likely to be procedures that took place in the Emergency Department. Furthermore, admissions of newborns where the admission type was the birth episode (ADMTYPE = 'Y') were excluded. Finally, admissions that took place entirely within the emergency department or Short Stay Unit were also excluded. There were no cases with short-stay-only admissions and a difficult/failed intubation code; presumably this meant that when a difficult or failed intubation occurred the patient was subsequently admitted.

The data were analysed using SAS software (SAS Institute Inc., Cary, NC, USA) determining risk based on denominator data generated by identifying the number of recorded general anaesthesia cases for each year and applying the selection criteria as listed above. Patient and surgery factors were identified, including the rates of difficult and failed intubation per age group and sex, as well as frequencies for comorbidities and surgery types. Logistic regression analysis was performed to determine the factors associated with difficult and failed intubation among hospital admissions with a recorded general anaesthesia procedure, including: age; sex; procedure type and patient comorbidities (including ASA and the Charlson Comorbidity Index). The Charlson Comorbidity Index [13] is a summary comorbidity measure that predicts the mortality of a patient by classifying comorbidities, with 0 having the highest chance of survival.

The Firth method (penalised likelihood) was applied to reduce small sample bias that can occur with relatively rare events. The model fit was evaluated using the Hosmer Lemeshow test and interaction effects were introduced to achieve a good model fit. Composite variables were created as an alternative to model interaction effects for ease of interpretation and presentation of the results. Because procedure type showed interaction effects with other model variables, and because many of the procedure types were relatively rare the modelling was carried out on the most common five types in a stratified analysis. These five procedure types made up 67% of all procedures.

Results

A total of 861,533 general anaesthesia cases were identified over the two years. This is comparable with previous figures for the state, suggesting approximately 1.1 million cases per year that also included neuraxial, regional anaesthesia and sedation cases not captured in the data we analysed. Of these, 4092 episodes of difficult or failed intubation were identified; only five cricothyroidotomy procedures were recorded. Failed intubation was relatively rare, occurring in 82 of the 4092 recorded failed/difficult intubation cases (2.0%). The incidence of failed or difficult intubation in 2015/16 and 2016/17 was 0.52% (95%CI 0.49–0.54) and 0.43% (95%CI 0.41–0.45), respectively.

Difficult/failed intubations occurred more frequently in males (0.59%) than females (0.38%). Furthermore, difficult and failed intubations were most pronounced in patients aged 45–74 y, with the highest incidence (0.79%) for patients aged 55–64 y (see Fig. 1). Over the age of 75 y the risk declined again, with the risk in patients aged 85 and older becoming lower than in patients aged 35–44 y.

Across all age groups procedures on the nervous system and endocrine system had the highest incidence of difficult and failed intubations. In contrast, dental procedures had the lowest rate of difficult/failed intubation across all age groups (Table 3). The 10 most common surgery types in each category are listed in Appendix S1. The rate of difficult/failed intubation was nearly double for emergency surgery (0.78%) compared to elective surgery (0.44%).

The presence and severity of comorbidities had a marked effect on the rate of difficult and failed intubation. The incidence of difficult/failed intubation more than doubled in patients who were obese (1.26%) compared to those who were not (0.47%, Fig. 2). The rate of difficult/failed intubations also increased for each subsequent ASA score, increasing threefold from ASA Score 1 (0.15%) to ASA score 2 (0.53%), more than fivefold from ASA score 1 to ASA score 3 (0.85%), and more than eight times higher in ASA score 4-6 (1.23%). Finally, the percentage of difficult/failed intubations more than doubled for patients with a Charlson comorbidity index of 1+ (0.94%) compared to patients with a Charlson comorbidity index of 0 (0.38%). Univariate logistic regression analysis found that age, sex, surgical procedure and comorbidity (i.e. ASA score, Charlson comorbidity index score, obesity) are all significant risk factors for a difficult/failed intubation ($p < 0.01$, Table 4). The fully adjusted logistic regression is presented in Table 5.

Across all procedures, males were at significantly higher risk of a difficult/failed intubation than females. The risk of a difficult/failed intubation for obese patients was increased in all procedures. Significant effects were found for musculoskeletal, gynaecological and urinary procedures ($p < 0.05$). The risk of a difficult/failed intubation for patients with obesity was most pronounced in urinary procedures (e.g. bladder examinations or endoscopic insertion of ureteric stents, see Appendix S1) and musculoskeletal procedures (e.g. knee or hip replacement).

The risk of a difficult/failed intubation was generally higher in emergency procedures than elective procedures across all ASA scores. This effect was significant for the vast majority of ASA score/procedure interactions. It was especially pronounced for patients with an ASA score of 4-6; the risk of a difficult/failed intubation in patients having an ASA score of 4-6 is up to five times as high in emergency procedures compared to elective procedures. This effect was especially pronounced for gynaecological procedures.

Discussion

The goal of this study was to determine the incidence and associated risk factors for failed and difficult intubation during general anaesthesia from a state-wide database. This was the first study that utilised the VAED and the ICD-10-AM classification for the purpose of identifying the incidence of airway management difficulties. The secondary goal was to explore how the VAED dataset (mostly used for hospital administrative and funding purposes) compared to existing incidence data on failed and difficult intubations, and thus identify whether it has the potential to complement other data sources.

While much research has investigated risk factors for difficult airway management, the findings of this study are novel due to the large number of cases studied and the inclusion of denominator data rather than a calculated estimate. The findings of this study suggest that the incidence of difficult/failed intubation is higher than has been previously reported by large-scale investigations such as the NAP4 study [1]. Indeed, NAP4 suggested that as few as one in three or one in four cases were captured during the audit. The differences are likely to be due to the different methods of data collection. The NAP4 report identified major airway management complications through self-reporting, whereas the VAED dataset is primarily used for administrative purposes. Due to the completeness of the VAED dataset, the denominator data is considered to be a reliable representation of the number of general anaesthesia cases carried out in Victoria, Australia.

To date, only a few studies have attempted to use databases that utilise ICD-10 coded data for the purpose of identifying the rate and risk factors for difficult/failed airway management. Li et al [14] used ICD-10 data to describe all-cause anaesthesia-related mortality rates in the USA between 1999 and 2005. Jones and colleagues [15] attempted to use ICD-10 coded data to identify airway management complications, but found that it did not accurately reflect the incidence of airway management complications. This was mainly due to ambiguity of the codes included in 'complications of anaesthesia'. Similarly, Palmer and colleagues [16] used ICD-10 coding to study airway management complications and also identified that the codes for complications were not explicit enough. Nevertheless, Palmer's study acknowledged that ICD-10 had potential to be improved if more distinctive codes for common complications were added. Conversely, the authors recognised that the T88.4 code for difficult intubation was frequently used in the UK between 2014 and 2015. It suggests that this particular code has some consistency in being both recorded by clinicians and recognised by coders. Our study is the first to analyse airway data at a population level since the ICD-10 was extended to include the T88.4 code in 2015. It now distinguishes between difficult and failed intubation in the Australian ICD-10 version (ICD-10-AM). We now believe the ICD-

10 coding system is reliable and specific enough to accurately examine rates and risk factors for difficult and failed airway management.

Triangulation of different data sources such as self-reports, litigation databases and observations may be useful to obtain a more realistic insight into the extent of the problem. However, as noted, these reports are often incomplete and rarely provide a denominator. In contrast to over 4000 cases identified as difficult or failed airway episodes in our data, the Victorian Consultative Committee for Anaesthetic Mortality and Morbidity (VCCAMM) reported only nine cases over an overlapping 3-year period (2015-2017) from the same geographical area [17]. These cases were from self-reports and included two deaths. While these reported cases may give a finer grained insight into the contributing factors and actions taken, they are clearly unreliable in helping to understand the extent of the problem.

We were unable to determine the fate of the 82 patients that experienced a failed intubation. Presumably they were rescued with a supraglottic airway or facemask ventilation until they were able to be woken. Voluntary reporting via the VCCAMM database for a 3-year period, including the two years we analysed, found nine airway-related airway cases with two deaths. Only three failed intubations were identified over three years in comparison to 82 over our 2-year study period, highlighting the significant level of underreporting with a voluntary system. Similarly, the VCCAMM report identified only two cases of emergency front of neck access over a 3-year period, compared to five cases over the two years of our database analysis. Despite this higher number, the limited details available from our methodology mean that these analyses are less useful than studies where finer-grained analyses were accessible [2]. Studies with self-reported cases allow deeper lessons to be learned from the narrative.

This study confirmed that sex is an independent predictor of difficult intubation, with females at lower risk than males [18, 19, 20]. A new finding is the discovery of a relatively low risk for difficult/failed intubations in older age groups (>75 y). This contradicts previous work and scoring systems that included older age (defined as over 55, 57 or 60) as an independent predictor for difficult intubation [19, 21]. Another study found that increased age was related to higher laryngoscopy grade and thus intubation difficulty [22]. Other research has shown that an age of mid-50s (55–57 y) and older was a significant predictor for difficult mask ventilation [23, 24]. In this study, the risk for difficult intubations peaked between 55 and 64 y (or younger, depending on the procedure type), but was lower in patients aged 75 y and older. This could be explained by the confounder of loss of teeth and use of dentures, or may be a 'healthy selection' for elective surgery that occurs at an older age. This means that only older patients (> 85 y) who are in good health are selected for elective surgery, whereas older patients presenting with poor health are likely to be

advised against undergoing the procedure. An alternative but similar explanation for older patients having relatively less difficult airway management is the 'compression of morbidity' effect [25]. This refers to compression of the lifetime disease burden into a shorter time period prior to the time of death by postponing the onset of chronic disease. Applied to the findings of this study, patients aged 55–65 y (both in poor and good health conditions) undergo surgery to postpone their onset of morbidity. This results in fewer older people requiring essential surgery at a later point in life (compression of morbidity). While these effects have been subject to previous study, there is usually a lack of detailed denominator data that makes it impossible to identify the incidence per age group, except where denominator data have been extrapolated, such as in NAP4.

Comorbidities (increased ASA score, obesity) and urgency of procedure were both strongly associated with difficult/failed intubation. This finding is in line with previous research findings. Ezri's group [18] found that an ASA score of 3 or higher was an independent risk factor for difficult intubation. The NAP4 report found that the majority of major airway management complications occurred in patients with an ASA grade 1 or 2 (56%) compared with 46% in this cohort [1].

The increased risk for difficult/failed intubation which this study found for patients with obesity is in line with the NAP4 report, where obesity was represented twice as often as in the generic UK population [18]. However, there is contradictory evidence regarding obesity as a risk factor for difficult intubation. Multiple studies have identified obesity as an independent risk factor for difficult airway management [20, 24, 26]. However, other research has suggested that obesity alone is not a predictive factor for difficult intubation [22, 27-29].

Our results also identify risk profiles for different types of surgical procedures. With the exception of cardiac surgery [19, 30], there is little research that has investigated the incidences of difficult intubation in different types of surgery. Across all age groups, procedures on the nervous and endocrine systems had the highest percentage of difficult/failed intubations, whereas dental procedures had the lowest rate. This study also found that the risk of difficult/failed intubations nearly doubled for emergency surgery compared to elective. However, in contrast to NAP4, nearly 90% of difficult airway episodes were in the elective group compared to 44% in the NAP4 data. This might again be due to reporting bias, with clinicians more likely to report emergency cases rather than elective cases where the opportunity to actively manage potential airway difficulty was not taken.

A limitation of the use of administrative hospital admissions data is that all diagnostic and procedure codes are listed in a hospital record, without information about sequence of events or settings in which the procedures occurred. Our method of identifying difficult airway episodes from the VAED does not account for the possibility that another failed/difficult intubation may have taken

place outside the surgery episode due to some other need to manage the airway before or after the procedure. However, reintubation after the procedure or emergent intubation before the procedure is likely to be unusual. Practically, from a data analysis point of view, it is challenging to relate the intubation code to a specific surgery type if the patient had more than one surgical procedure in one admission. This study selected the first listed procedure as the main surgery for which the patient was admitted.

A generic limitation of the ICD-10 data is that this classification system does not provide information about outcomes related to a particular ICD-10 code. This study is unable to provide insight into the severity or clinical outcomes of the difficult/failed intubations, in contrast to more detailed self-reported methodologies such as incident reporting databases or the NAP4 project. The ICD-10 definition of the difficult intubation code is also not defined further, or specified in relation to attempts or type of airway manoeuvres. Therefore, it is challenging to compare the results from the ICD-10 with other research that has more narrowly defined difficult intubation. Similarly, because difficult intubation related to general anaesthesia was specified in the data extraction, the data analysed in this study does not capture cases where general anaesthesia (and intubation) was avoided because of the potential for a difficult airway. It does, however, capture cases where general anaesthesia was performed and a supraglottic airway was inserted, or cases where awake tracheal intubation or elective tracheostomy were performed as part of the difficult airway management.

Because the VAED is used for health service planning and hospital funding it can be assumed that the data is less likely to be incomplete than from other data sources. However, hospital data such as the VAED is affected by policy and administration change, which mainly affects denominator data. In this situation, episodes of general anaesthesia are probably well captured and it is unlikely that any policy change has affected internal consistency in the present study.

The VAED dataset, which is predominantly utilised for administrative purposes, has proved useful to study airway management incidents. This study showed that ASA score, obesity and procedure types are strong predictors for difficult intubations. We have successfully determined risk factors for difficult intubation across different age profiles, offering new insights into the relatively low risk of difficult intubations for older patients. Databases such as the VAED complement other data sources based on self-reporting, observations and litigation. The recent distinction between the ICD-10-AM codes for difficult and failed intubation was useful and further broadened the data set. Nevertheless, failed intubation occurred too rarely in the present sample to build a valid statistical model and analyse separately from difficult intubations. Within the scope of the discussed limitations, the VAED and similar national administrative hospital data sets should be more

frequently considered as an additional valuable data source to study the incidence of airway management difficulties. As this study has demonstrated, this type of data source has the potential to further progress our knowledge of the heightened risk related to demographics, comorbidities and surgery characteristics.

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Table 1 Definitions of ICD-10-AM codes used in the present study

ICD-10-AM code	Injury description	Definition*
T88.41	Failed intubation	Failed endotracheal intubation requiring emergency airway management procedures (cricothyroidotomy/cricothyrotomy) (tracheostomy) ***Excludes:*** during: • labour and delivery • pregnancy •the puerperium (postpartum)

T88.42	Difficult intubation	Difficult intubation

* Retrieved from the ICD-10-AM, 9th edition, version 2.4

Table 2 Frequency of difficult/failed intubations (per general anaesthesia per year) by age group and sex.

	Total		Difficult or failed intubation*	
	n	Column %	n	Row %
Age group; y				
0-4 **	35,037	4.1%	37	0.11%
5-14	52,003	6.1%	25	0.05%
15-24	90,770	10.6%	106	0.12%
25-34	104,102	12.1%	218	0.21%
35-44	115,189	13.4%	479	0.41%
45-54	121,544	14.2%	851	0.70%
55-64	126,983	14.8%,	1012	0.79%
65-74	123,463	14.4%	908	0.73 %
75-84	67,795	7.9%	386	0.57 %
85+	20,555	2.4%	70	0.34%
Sex				
Female	468,126	54.6%	1790	0.38%
Male	389,287	45.4%	2302	0.59%
Year				
2015/16	420,716	49.1%	2193	0.52%
2016/17	436,725	50.9%	1899	0.43%
Total	861,533	100.0%	4092	100.0%

* Absolute number of cases within each category, as well as the percentage of all general anaesthesia cases in Victoria within the given category; ** The age group 1-4 was not further differentiated due to the small number of difficult/failed intubations identified.

Table 3 Frequency of difficult/failed intubations (per general anaesthesia per year) by surgery type and comorbidities.

	Total		Difficult or failed intubation*	
	n	Column %	n	Row %
Surgical procedure †				
Procedures on nervous system	28,131	3.3	460	1.64
Procedures on endocrine system	6973	0.8	120	1.72
Procedures on eye and adnexa	8875	1.0	10	0.11
Procedures on ear and mastoid process	16,335	1.9	28	0.17
Procedures on nose, mouth and pharynx	48,139	5.6	194	0.40
Dental services	49,663	5.8	23	0.05
Procedures on respiratory system	11,371	1.3	137	1.20
Procedures on cardiovascular system	33,303	3.9	289	0.87
Procedures on blood and blood-forming organs	4269	0.5	23	0.54
Procedures on digestive system	158,798	18.4	1364	0.86
Procedures on urinary system	54178	6.3	204	0.38
Procedures on male genital organs	33,835	3.9	108	0.32
Gynaecological procedures	118,357	13.7	262	0.22
Obstetric procedures	5052	0.6	26	0.59
Procedures on musculoskeletal system	185,131	21.5	605	0.33
Dermatological and plastic procedures	59,710	6.9	152	0.25
Procedures on breast	23,007	2.7	52	0.23
Radiation oncology procedures	808	0.1	<5	-
Non-invasive, cognitive and other interventions, not elsewhere classified	11,104	1.3	24	0.22
Imaging services	4494	0.5	<10	-
Charlson comorbidity index				
0	717,099	83.2	2734	0.38
1+	144,434	16.8	1358	0.94
Obesity				
No	853,110	99.0	3986	0.47

Yes	8423	1.0	106	1.26
ASA score				
1	327,413	38.0	499	0.15
2	331,716	38.5	1765	0.53
3	175,085	20.3	1491	0.85
4-6	27,319	3.2	337	1.23
Emergency procedure				
Procedure performed as an emergency	99,353	11.5	775	0.78
Non-emergency or not known	762,180	88.5	3317	0.44
Totals	861,533	100.0	4092	0.47

* Absolute number of cases within each category, as well as the percentage of all general anaesthesia procedures in Victoria within the given category; † Based on the first listed ACHI block code.

Table 4 Factors associated with difficult or failed intubation univariate modelling. Values are OR (95%CI).

Age group; y		
0-4	0.24	((0.18-0.36)
5-14	0.12	(0.08-0.18)
15-24	0.28	(0.23-0.35)
25-34	0.50	(0.43-0.59)
35-44	1	(REF)
45-54	1.68	(1.50-1.88)
55-64	1.92	(1.72-2.14)
65-74	1.77	(1.58-1.98)
75-84	1.37	(1.20-1.57)
85+	0.82	(0.64-1.06)
Sex		
Female	0.65	(0.61-0.69)
Male	1	(REF)
Year		
2015/16	1.20	(1.13-1.28)
2016/17	1	(REF)
Surgical procedure †		
Procedures on nervous system	1.92	(1.73-2.14)
Procedures on endocrine system	2.03	(1.68-2.45)
Procedures on eye and adnexa	0.14	(0.07-0.25)
Procedures on ear and mastoid process	0.20	(0.14-0.29)
Procedures on nose, mouth and pharynx	0.47	(0.40-0.54)
Dental services	0.06	(0.04-0.08)
Procedures on respiratory system	1.41	(1.18-1.69)
Procedures on cardiovascular system	1.01	(0.89-1.15)
Procedures on blood and blood-forming organs	0.64	(0.42-0.96)
Procedures on digestive system	1	(REF)
Procedures on urinary system	0.44	(0.38-0.51)
Procedures on male genital organs	0.37	(0.31-0.45)

Gynaecological procedures	0.26	(0.23-0.29)
Obstetric procedures	0.61	(0.41-0.89)
Procedures on musculoskeletal system	0.38	(0.34-0.42)
Dermatological and plastic procedures	0.30	(0.25-0.35)
Procedures on breast	0.26	(0.20-0.35)
Radiation oncology procedures	0.36	(0.10-1.24)
Non-invasive, cognitive and other interventions, not elsewhere classified	0.26	(0.17-0.38)
Imaging services	0.24	(0.13-0.46)
Charlson comorbidity index		
0	1	(REF)
1+	2.48	(2.32-2.65)
Obesity		
No	1	(REF)
Yes	2.73	(2.25-3.31)
ASA score		
1	1	(REF)
2	3.50	(3.17-3.87)
3	5.62	(5.08-6.22)
4-6	8.19	(7.13-9.41)
Emergency procedure		
Procedure performed as an emergency	1.80	(1.66-1.95)
Non-emergency or not known	1	(REF)

* Variables are kept if p<0.01; † Based on the first listed ACHI block code.

Table 5 Factors associated with difficult or failed intubation: fully adjusted modelling. Values are OR (95%CI).

	Procedures on musculoskeletal system 605/185,128		Procedures on digestive system 1364/158,797		Gynaecological procedures § 262/118,353		Dermatological and plastic procedures 152/59,708		Procedures on urinary system 204/54,178	
Age group, y										
0-4	0.34	(0.10-1.21)	0.43	(0.23-0.81)	0.88‡	(0.06-13.55)	1.02	(0.42-2.48)	0.49	(0.10-2.52)
5-14	0.23	(0.11-0.50)	0.06	(0.02-0.20)			0.27	(0.07-0.98)	0.16	(0.01-2.55)
15-24	0.47	(0.29-0.77)	0.32	(0.22-0.48)	0.28	(0.11-0.71)	0.94	(0.50-1.76)	0.27	(0.05-1.36)
25-34	0.53	(0.33-0.84)	0.53	(0.41-0.70)	0.45	(0.28-0.73)	0.77	(0.40-1.49)	0.93	(0.47-1.84)
35-44	1	(REF)	1	(REF)	1	(REF)	1	(REF)	1	(REF)
45-54	1.29	(0.93-1.78)	1.38	(1.14-1.66)	1.51	(1.09-2.09)	1.20	(0.71-2.02)	0.72	(0.44-1.20)
55-64	1.28	(0.94-1.75)	1.25	(1.04-1.51)	1.21	(0.81-1.80)	0.78	(0.44-1.36)	0.62	(0.38-0.99)
65-74	1.12	(0.81-1.54)	0.94	(0.77-1.14)	1.26	(0.81-1.94)	0.50	(0.28-0.92)	0.58	(0.37-0.92)
75-84	0.89	(0.61-1.29)	0.77	(0.61-0.98)	0.82	(0.42-1.59)	0.22	(0.10-0.51)	0.08	(0.04-0.18)
85+	0.63	(0.37-1.07)	0.47	(0.30-0.72)	0.19	(0.01-2.95)	0.08	(0.02-0.43)	0.07	(0.02-0.27)
Sex										
Female	0.69	(0.58-0.81)	0.77	(0.69-0.86)			0.54	(0.39-0.76)	0.65	(0.47-0.88)
Male	1	(REF)	1	(REF)			1	(REF)	1	(REF)
Year										
2015/16	1.09	(0.93-1.28)	1.35	(1.21-1.50)	1.23	(0.97-1.56)	1.38	(1.01-1.89)	0.96	(0.73-1.25)

2016/17	1	(REF)	1	(REF)	1	(REF)	1	(REF)	1	(REF)
Charlson comorbidity index										
0	1	(REF)	1	(REF)	1	(REF)	1	(REF)	1	(REF)
1+	1.08	(0.87-1.33)	1.26	(1.11-1.44)	2.56	(1.88-3.48)	1.01	(0.68-1.51)	2.30	(1.71-3.11)
Obesity										
No	1	(REF)	1	(REF)	1	(REF)	1	(REF)	1	(REF)
Yes	4.07	(2.03-8.13)	1.03	(0.80- 1.33)	3.32	(1.28-8.61)	2.05	(0.41-10.30)	9.31	(3.79-22.89)
Emergency procedure †										
A normal healthy patient	3.74	(2.40-5.84)	3.80	(2.82-5.11)	1.17	(0.40-3.44)	0.98	(0.41-2.36)	4.16	(1.58-10.97)
A patient with mild systemic disease	5.63	(3.76-8.43)	5.39	(4.19-6.93)	3.50	(1.45-8.42)	2.60	(1.26-5.39)	2.80	(1.12-7.01)
Patient with a severe systemic disease that limits activity	5.78	(3.70-9.04)	5.09	(3.85-6.72)	3.13	(0.63-15.67)	9.05	(4.46-18.37)	4.51	(2.13-9.54)
Patient with a severe systemic disease that is a constant threat to life	8.45	(4.70-15.19)	3.98	(2.68-5.92)	20.51	(5.60-75.07)	18.10	(5.63-58.18)	4.36	(1.47-12.99)
Non-emergency or not known										
A normal healthy patient	1	(REF)	1	(REF)	1	(REF)	1	(REF)	1	(REF)
A patient with mild systemic disease	2.87	(2.11-3.90)	2.45	(1.97-3.04)	3.24	(2.29-4.58)	3.00	(1.77-5.10)	2.03	(1.15-3.57)
Patient with a severe systemic	5.31	(3.83-7.37)	2.99	(2.37-3.78)	4.25	(2.76-6.52)	7.41	(4.16-13.20)	2.71	(1.50-4.89)

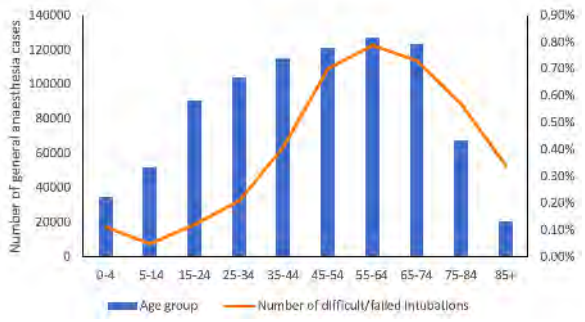
disease that limits activity										
Patient with a severe systemic disease that is a constant threat to life	7.29	(4.08-13.03)	4.51	(3.04-6.68)	4.28	(1.18-15.50)	13.61	(4.78-38.76)	1.36	(0.42-4.40)

* Variables are kept if p<0.01; † Composite variable made by combining the ASA group and Emergency Procedure variables; § Females only are included in this model; ‡ Age groups 0-4 & 5-14 years are grouped in the gynaecological procedures analysis because of low cell counts in the youngest age group.

Figure legends:

Figure 1 Frequency of difficult/failed intubations per age group in Victoria, Australia, 2015/16 - 2016/17.

Figure 2 Number of difficult/failed intubations per comorbidity measure, presented as the percentage contributing to the total number of anaesthesia cases



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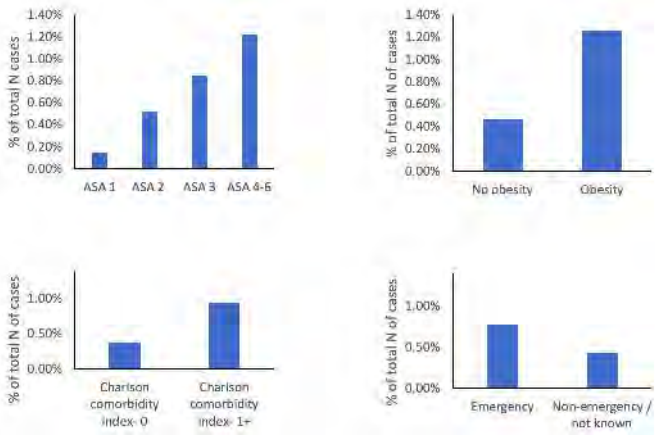

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