Original article

Journal of the Intensive Care Society
2019, Vol. 20(3) 248–254

DOI: 10.1177/1751143718801706
journals.sagepub.com/home/jics

The provision of central venous access, transfer of critically ill patients and advanced airway management: Are advanced critical care practitioners safe and effective?

Gavin Denton, Lindsay Green, Marion Palmer, Anita Jones, Sarah Quinton, Simon Giles, Andrew Simmons, Andrew Choyce, Sean Munnelly, Daniel Higgins, Gavin D Perkins and Nitin Arora

Abstract

Advanced critical care practitioners are a new and growing component of the critical care multidisciplinary team in the United Kingdom. This audit considers the safety profile of advanced critical care practitioners in the provision of central venous catheterisation and transfer of ventilated critical care patients without direct supervision and supervised drug assisted intubation of critically ill patients. The audit showed that advanced critical care practitioners can perform central venous cannulation, transfer of critically ill ventilated patients and intubation with parity to published UK literature.

Keywords

Advanced critical care practitioner, central venous cannulation, rapid sequence intubation, transfer of the critically ill patient

Introduction

In 2008, the Department of Health published 'The National Education and Competence Framework for Advanced Critical Care Practitioners' in response to concerns regarding short falls in the medical workforce for critical care services in the United Kingdom.[1] Since the inception of the advanced critical care practitioner (ACCP) role, some individual National Health Service trusts began to develop a medical workforce that integrate ACCPs into the critical care medical team. In 2016, only 15% of 239 surveyed critical care units (ICU) had ACCPs as part of their ICU medical workforce.[2] ACCPs are a small, but steadily growing collective of health care professionals. In 2015, the Faculty of Intensive Care Medicine (FICM) produced a framework for accrediting trained ACCPs and a new training standard, competency, and revalidation framework for ACCP trainees.[3]

The role of the ACCP within the multidisciplinary team (MDT) is diverse, encompassing clinical examination, ordering of investigations, procedures, formulation of plans of care, and many other medical and administrative tasks which a critical care service requires to function.[4] This does not mean to say that the ACCP is a task-orientated technician; Health Education England have produced a framework for advanced clinical practice, asserting that four pillars underpin the role: clinical practice, management, leadership and education/research.[5] ACCPs are integral to communication within the MDT, support and communication of both patients and loved ones, provision of end-of-life care, rehabilitation and post-ICU discharge support. The consistent presence of ACCPs also creates a resource for clinical supervision/education for junior doctors, nurses and the wider MDT. The ability of a service to provide long-term audit,

Critical Care Unit, Heartlands Hospital, University Hospitals, Birmingham, UK

Corresponding author:
Gavin Denton, Critical Care Unit, Heartlands Hospital, University Hospitals, Birmingham, UK.
Email: gdenton1@yahoo.co.uk

quality improvement and participate in research is enhanced by the continuous presence of ACCPs.

The insertion of invasive lines for therapy and monitoring, transfer of critically ill patients and supervised advanced airway management are within the skill set and competency framework of the ACCP.[3] There are no published papers on the safety profile of adult ACCPs in the performance in these aspects of critical care delivery. In order to have a better understanding of the contribution of ACCPs to our critical care service delivery and their safety profile, we designed an audit to compare the frequency and outcomes of these procedures for comparison with the published literature.

Methods

Advanced critical care practitioner team

The ACCP team was established in 2011 and now comprises a nurse consultant and eight ACCPs. All of the team are from a critical care nursing background, with a range of experience from 8 to over 15 years of critical care exposure prior to commencing training. The experience of the ACCP team members was across multiple critical care units, across different specialities. Team members also had extensive experience in resuscitation; most of the team were advanced life support instructors prior to joining the team.

Training and development programme

The ACCP training programme was designed to cover the requirements outlined in the National Education and Competence Framework for Advanced Critical Care Practitioners.[1] The programme included completion of an academic component (Master's degree) and supervised clinical practice. This eight-module Masters programme, hosted by the University of Warwick, includes clinical examination and history taking, diagnostics and investigation, transfer of the critically ill, advanced emergency practice and non-medical prescribing.[6] Each clinical module requires participants to complete a portfolio of experience, procedures, reflective accounts, direct observation of procedural of skills and feedback.

In practice, clinical supervision was provided by intensive care consultants and senior trainees. ACCPs worked through a structured supervision programme for each component of the curriculum. The programme progressed through demonstration of relevant knowledge, direct supervision to indirect supervision. When the ACCP was able to perform fully independently without any direct consultant input or monitoring, they were signed off for independent practice in that area. All practice is indirectly supervised at all times. Through the course of the 2-year programme, ACCPs progressed through the full curriculum defined by the National Framework. The team members have subsequently been accredited by the FICM Advanced Critical Care Practitioner Programme. Three core practical skills undertaken by ACCPs are central venous access line insertion, advanced airway management and transfer of the critically ill patient. Central venous access and transfers are undertaken independently by ACCPs without direct supervision. Central venous cannulation is performed in accordance with the Association of Anaesthetists of Great Britain and Ireland guidelines and includes the use of ultra-sound scanning, full aseptic technique and post line care.[7] Patients requiring internal or external hospital transfer were assessed for the safety of the intended transfer and managed in accordance with the Intensive Care Society Transfer Guidelines.[8] Typically, patients being transferred by the ACCP team were intubated and haemodynamically stable.

Advanced airway management for patients requiring rapid sequence induction was undertaken jointly between an ACCP and critical care senior trainee or consultant. Patient assessment, decision to proceed with intubation, followed national guidelines. During advanced airway management, pharmacological treatment and team leadership fell to the medical practitioner. The ACCP had first attempt at intubation in these cases.

Data collection

Data collecting tools were developed to capture information about the frequency with which ACCPs were undertaking advanced procedures, the indications for procedures and outcomes. Data were collected securely and in an anonymised form using Google Forms (California, USA). Only procedures undertaken by fully qualified ACCPs are included in the audit.

The audit of central venous cannulation was based on the Intensive Care National Audit Project-1 and collected information on the indication for the procedures, type of line inserted, physical environment where the line was inserted, anatomical site of attempted insertion, number of attempts, success and any complications.[9]

The transfer audit collected information on the date, time and indication for patient transfer. Patient information (severity of underlying illness), transfer destination and any complications which arose during the transfer were also captured.

The airway audit captured the indications, role of the ACCP and outcomes of emergency intubations outside of the theatre environment, including all rapid sequence inductions (RSI) and cardiac arrests. The audit tool was based on the New Zealand Emergency Medicine Network-Australian New Zealand Emergency Department Airway Registry audit and covered data and time of event, indications, location, first pass success rate,

Cormack Lehane grade, use of airway adjuncts and any complications (respiratory, cardiovascular, trauma, death).[10]

Analysis

Data are presented using simple descriptive statistics. Categorical data are summarised by the number in each category and percentage of the group as a whole.

Approvals

The audits were approved by the Trust Audit committee (reference 4461). Gavin Denton developed the online audit tool and led the audit under the supervision of the critical care audit lead Nitin Arora.

Results

The audit cycle ran from December 2016 to February 2018. The current ACCP team consists of nine members. Two of the members qualified as ACCPs part way through the audit; therefore, only a small proportion of their activity was incorporated into the data set, and trainee ACCP data were omitted.

Central venous cannulation

During the audit period, ACCPs inserted 248 CVCs, representing 56.2% of all CVCs inserted by the critical care service. The majority (64.9%) of CVC insertions occurred out of hours 17:00 h to 08:00 h. Dialysis lines and multi-lumen CVCs were the most frequent types of line inserted, and were largely placed within the critical care areas. A range of anatomical sites were used for insertion; however, our service infrequently uses the sub-clavian site. The success rate for a CVC attempt was 95.9%; first pass success was achieved in 84.6% of cases, with 93.1% of lines inserted without complication. The most common complication was arterial puncture (2.4%) and catheter tip malposition (usually associated with peripherally inserted central venous catheters (PICC)). Compliance with the unit's CVC insertion bundle (sterile gloves and gown, cap and mask, chlorhexidine and ultrasound) was 92.3%.

Table 1. Central venous catheterisation.

Number of CVC insertions	248
Clinical course	32 (12.9%)
Difficult access	22 (8.8%)
Vasopressor support	111 (44.7%)
Thrombophlebitic drugs	4 (1.6%)
RRT	68 (27.4%)
TPN	11 (4.4%)
Line type	
CVC	137 (55.2%)
Dialysis line	75 (30.2%)
Haemolung[a]	1 (0.4%)
PICC	35 (14.1%)
Location	
HDU	28 (11.2%)
ICU	170 (68.5%)
ED	19 (7.6%)
Other (such as a designated procedure room)	31 (12.5%)
Site of insertion	
Internal jugular	158 (63.7%)
Femoral	52 (20.9%)
Subclavian	3 (1.2%)
PICC	35 (14.1%)
Successful insertion	238 (95.9%)
Compliance with CVC insertion bundle (including cap, gown, mask, USS, chlorhexidine)	229 (92.3%)
Complications	
No complications	231 (93.1%)
Arterial puncture	6 (2.4%)
Catheter tip displacement	8 (3.2%)
Haematoma	1 (0.4%)
Other[b]	3 (1.2%)
First pass success	210 (84.6%)

ED: emergency department; HDU: high dependency unit; PICC: peripherally inserted central venous catheter; RRT: renal replacement therapy; TPN: total parenteral nutrition; USS: ultra-sound scan.
[a]Haemolung catheters inserted under indication 'clinical course'.
[b]Two failures to pass guidewire, insertion attempts abandoned. One alternative site of insertion used after failed attempted insertion.

Transfer activity

ACCPs carried out 325 transfers of patient in receipt of mechanical ventilation without direct medical supervision. These transfers occurred out of hours (17:00–08:00) in 56.6% of events. Internal transfers constituted 73.5% of transfers. Imaging was the most frequent reason for internal transfers, and this included computerised tomography (CT) and magnetic resonance imaging scans. In terms of acuity of patients requiring internal transfer, 52.7% required vasopressor support, 38.9% required more than 50% oxygen and 9.2% required a positive end expiratory pressure of more than 10 cm of water. Uneventful transfer comprised 91.6% of cases, hypotension was the most common complication during transfer, which occurred at a rate of 2.92%, and this was followed by hypoxia with a frequency of 1.6%.

External transfers comprised 26.4% of ACCP transfers. All of which required ambulances to transport the patient to another site within the trust or to a tertiary centre for specialist care. The absence of an available ICU bed in the primary hospital was the main indication for external transfer. Tertiary transfers constituted 27.9% of external transfers, and these were largely for specialist neurosurgical management. Compared to the internal transfers, external cases were more likely to require vasopressor support

Table 2. Transfer of invasively ventilated patients.

	Internal transfer	External transfer
Transfer type	239	86
Location		
HDU	7 (2.9%)	19 (22.1%)
ICU	150 (62.8%)	19 (22.1%)
ED	61 (25.5%)	40 (46.5%)
Other	21 (8.7%)	8 (9.3%)
Checklist completed	160 (69%)	63 (76.8%)
Indication		
Imaging	194 (81.2%)	–
No bed in current hospital	–	55 (63.9%)
Transfer from resus to ICU	25 (10.5%)	–
Specialist bed within the trust	17 (7.1%)	5 (5.8%)
Tertiary specialist transfer	–	24 (27.9%)
Repatriation	–	2 (2.3%)
Other	3 (1.3%)	–
Cardiovascular support		
Vasopressor support	126 (52.7%)	60 (69.7%)
Arrhythmia	11 (4.6%)	5 (5.8%)
>1 inotrope	6 (2.51%)	3 (3.4%)
IABP	2 (0.83%)	2 (2.3%)
Transfusion in transit	2 (0.83%)	1 (1.1%)
Respiratory support		
>50% O_2	93 (38.9%)	51 (59.3%)
No additional support[a]	68 (28.4%)	13 (15.1%)
PEEP > 10	22 (9.2%)	15 (17.4)
PCO_2 > 8	5 (2.0%)	5 (5.8%)
APRV	2 (0.83%)	3 (3.4%)
Other	6 (2.5%)	–
Complications		
Uneventful	219 (91.6%)	80 (93%)
Hypotension	7 (2.93%)	3 (3.5%)
Equipment failure	4 (1.6%)	1 (1.2%)
Hypoxia	4 (1.6%)	–
Defibrillation	–	–
Change in neurology	1 (0.4%)	–
Forgotten/absent equipment	1 (0.4%)	–

APRV: airway pressure release ventilation; ED, emergency department; HDU: High dependency unit; IABP: intra-aortic balloon pump; ICU: intensive care unit; pCO_2: partial pressure of carbon-dioxide; PEEP: positive end expiratory pressure; RESUS (resuscitation bay of the emergency department).
[a]No additional support means single organ support, ventilation only, with no other ventilation acuity markers such as >50% oxygen.

Table 3. Rapid sequence induction.

Total number of RSI intubations	190
Indication	
Respiratory failure	85 (44.7%)
Low GCS	35 (18.4%)
Post arrest	16 (8.4%)
Imaging	18 (9.4%)
Shock	10 (5.2%)
Airway displacement	7 (3.6%)
Airway obstruction	6 (3.1%)
GI bleed	4 (2.1%)
Seizure	3 (1.5%)
Cardioversion	2 (1%)
Overdose	3 (1.5%)
Head injury	1 (0.5%)
Location	
HDU	13 (6.8%)
ITU	91 (47.8%)
ED	54 (28.4%)
General wards	32 (16.8%)
First pass success	170 (89.4%)
Cormack Lehane	
Grade 1	137 (72%)
Grade 2	38 (20%)
Grade 3	13 (6.8%)
Grade 4	–
Missing data	2
Second practitioner required to intubate	9 (4.7%)
Complications	
No complications	153 (80.5%)
Hypotension	18 (9.4%)
Spo2 < 93%	15 (7.8%)
Recognised oesophageal intubation	4 (2.1%)
Cardiac arrest	3 (1.5%)
Other	2 (1%)
Equipment failure	2 (1%)
Dental trauma	2 (1%)
Death	1 (0.5%)
Aspiration post induction	1 (0.5%)
Use of bougie	102 (53.4%)
C. spine immobilisation	2 (1%)

C. spine: cervical spine; ED: emergency department; GCS: Glasgow coma scale; GI: gastro-intestinal; HDU: high dependency unit; ICU: intensive care unit; RESUS: resuscitation bay of the emergency department).

(69.7%) and required greater than 50% oxygen and a PEEP > 10. The external transfer cohort appeared to have greater acuity; however, 93% of these transfers were uneventful. Hypotension was the most common complication (3.5%). There were no adverse airway events, including extubation in either of the transfer groups.

Advanced airway management

The ACCPs were involved in providing advanced airway management (intubation) for 190 patients, all of which were drug assisted, with direct supervision from a registrar or consultant. Only 35.3% of intubations occurred during normal working hours (08:00–17:00), so the bulk of intubations were carried out by on-call teams out of hours. Neuromuscular blockade was administered in 95.7% of cases, and 81% were paralysed with rocuronium. An anaesthetic induction agent was used in 95.2% of cases, propofol being the most common agent (77.9%), with ketamine being the

second most frequently used agent (17.1%). Respiratory failure was the most common indication for intubation (44.7%). Most intubations were carried out in ICU (47.8%) followed by the emergency department. The first pass success rate was 89.4%, with 4.7% of intubations requiring a second operator. The number of uneventful intubations was 80%, the most common complication being hypotension (systolic blood pressure less than 90 mmHg, 9.4%). The second most frequent complication was hypoxia (oxygen saturation less than 93%), 7.8% of patients experienced this. There were no unrecognised oesophageal intubations, and four recognised oesophageal intubations (2.1%). Cardiac arrest following induction occurred in 3 patients which represented 1.5% of cases. One death occurred following induction (0.5%).

Discussion

A significant proportion of central venous access, transfer of the critically ill and elements of advanced airway management are carried out by ACCPs in this service (52.9%, 90.7% and 66.5% respectively). To our knowledge, this is the first publication considering the practice and safety profile of this new addition to the multidisciplinary critical care team. The incidence of complications during these activities is in keeping with published literature and compares well with data previously reported from the UK.

Two recent Cochrane reviews assessed success rates and complications associated with central venous access (subclavian, internal jugular and femoral) under ultrasound guidance. From pooled data, from 48 studies examining 7449 line insertions, the first pass success rates of 78% compared favourably with those found in this audit (85%).[11,12] Similarly, the overall success rate in Cochrane studies (93%) was similar to those in this audit (95.9%).[11,12] The pooled complication rate from the Cochrane reviews was 5.8% (compared to 6.9% in this audit) with a similar profile of complications (arterial puncture 4.0%, haematoma 1.2%).[11,12] These are concordant with data from two recent UK studies which reported complication rates of 3.1% and 6.8%, respectively.[9,13] The less than 100% compliance with best practice recommendations (personal protective equipment, ultrasound, chlorhexidine) is a concern. There is a lack of granular information in the audit to unpick the specific types and reasons for non-compliance. CVC insertions in non-critical care areas may result in inconsistent availability of equipment and are a likely factor here, especially in our emergency department. Future evaluations should capture more detailed information and act as a focus for quality improvement.

The National Institute for Health and Care Excellence (NICE) recently evaluated internal and external hospital transfers.[14] The review noted a paucity of evidence to inform the optimal approach to transfer. The type and frequency (10–24%) of complications varied between studies due to differences in study design and definition of complications. Complications associated with transfers can be broadly categorised into those relating to patient factors (severity of illness, comorbidities, interventions), system factors (transfer distance, equipment failure, absence of checklists) and staff factors (communication, insufficient training, inadequate resuscitation, unsecured devices).[15,16] NICE reported very low quality evidence supporting the use of specialist transfer teams and checklists, two systems already adopted as part of the ACCP led transfer service.[14] This may, in part, explain the relatively low rate of adverse events (<10%) reported in this audit.

First pass success (FPS) has been used as a primary marker of safety for intubation in the context of an emergency setting. Sakles[17] found a significant increase in the frequency of complications with an increasing number of attempts at laryngoscopy, escalating to 70% complication rate at the third attempt at intubation. The seminal NAP4 audit identified that repeated failed attempts of laryngoscopy were correlated with adverse events.[18] An Australian group found in an international meta-analysis that the minimum FPS that should be used to benchmark airway management is 84%.[19] There have been a number of UK-based audits that have considered FPS in the context of intubation in critically ill patients. An unpublished audit of intubation by a Scottish critical care service found a FPS rate of 90%.[20] One of the largest registries of emergency intubation, also a Scottish study, found that emergency physicians had a FPS of 82%.[21] More recently, an audit presented at the Intensive Care Society State of the Art 2017 found an FPS in the order of 88% for intubation of the critically ill.[22] Simpson and Ross[23] achieved a 92% FPS rate for critical care units in Scotland. In this context, the ACCP FPS of 88% appears to contrast well with the UK published literature. Complications during intubation seem comparable with the same literature base. Simpson and Ross[23] identified severe hypotension and hypoxia of 20% in their cohort. Hypoxia and hypotension occurred at a frequency of less than 10% each in this audit, and the threshold for these outcomes was set lower. In this population, a complication rate in the order of 20% seems commonplace, although there are no set definitions which makes like for like comparison difficult. One may be drawn to the frequency of cardiac arrest in this cohort (1.5%); however, where such data have been included, the frequency of this event is also comparable to UK literature.[23]

Intubation carried out by ACCPs in this service is always under the supervision of a clinician qualified to provide independent drug assisted intubation. In this context, the induction is usually administered by the anaesthetist. Conversely, where an ACCP is present and an anaesthetist is carrying out the laryngoscopy,

the ACCP will usually administer the induction. This team approach to emergency intubation with two intubators is now endorsed by the recent Difficult Airway Society (DAS) guidance for the intubation of critically ill patients.[24,25]

To our knowledge, this is the first published evidence of the contribution of ACCPs to the delivery of critical care procedures and processes within a mature and established team. Anecdotally, the standards of practice within our team were considered to be high, but we did not have evidence for this. This work could set an initial benchmark for other services looking to develop a critical care service that integrates ACCPs into its MDT. Some doctors continue to voice concerns about the potential implications for standards and patient safety with the introduction of non-traditional medical roles. These data provide a basis to argue that, within an appropriate training curriculum, governance and with consultant oversight, ACCPs can be a safe and effective addition to the critical care medical workforce.

The data for this audit are collected prospectively and submitted by the individual performing the procedure or process. Recall bias is a particular problem for transfer and intubation complications whereby individuals may not accurately recall and document observation parameters or deliberately not document adverse events. ACCPs are not present at all critical care intubation and this set the scene for selection bias. In particular, there is the potential that predicted difficult airways may be more likely to be carried out by anaesthetists rather than ACCPs, these data cannot correct for this confounding. Nearly all critical care transfers are conducted by ACCPs, and in this context selection bias is less of an issue, although problem of recall bias remains. Our service does not have a system to reliably capture the three key areas of interest; therefore, it is difficult to identify missed cases.

The provision of central venous access by non-doctors is not a new concept; in fact, many hospitals have elective vascular access services where procedures are frequently carried out by non-doctor clinicians. However, transfer of intubated critically ill adults and advanced airway management is new to adult critical care, despite being common place in neonatal critical care for many years. This evidence supports the argument that, at least in regard to transfer, this can be done to a high standard by ACCPs and may guide other service developments. The provision of advanced airway management by non-medical personnel is even more contentious in the UK, although well established in pre-hospital care in the USA, Canada and Australia. The new DAS guidelines for intubation of critically ill adults puts far more emphasis on the team design and human factors than in the past, and ACCPs could be an important addition to this dynamic.[26]

The external validity of this audit is limited due to its single centre design. A larger regional or national study is required to review standards and formulate best practice.

The FICM credentialing process provides a minimum standard of education and supervision for the training and revalidation of ACCPs. However, the roles that ACCPs carry out in practice vary significantly from service to service, often depending on the maturity of the team. Further work is needed to identify the structures and training that ACCP teams have in place to progress towards transfer of critical care patients and airway management rather than siloed approaches to service development. Surveying established ACCP teams with regard to their roles and how they have developed their transfer and airway provision would help validate safe services and provide role models to new and evolving teams.

Conclusion

Within an accredited training curriculum, governance structure and consultant oversight, ACCPs can safely and effectively deliver CVC insertion, critical care transfer and supervised airway management. Further study is required to show how ACCPs perform on a national level and to provide benchmarking of standards and identify best practice.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Gavin Denton http://orcid.org/0000-0002-2504-438X
Sarah Quinton http://orcid.org/0000-0002-4289-0297
Nitin Arora http://orcid.org/0000-0001-9941-8340

References

1. Department of Health. *The national education and competence framework for advanced critical care practitioners*. A discussion document. London: Department of Health, 2006.
2. Simpson S, Platts J and Boulanger C. The Advanced Critical Care Practitioner role: a realistic workforce solution for ICU? From small Acorns. … | Intensive Care Society State of the Art 2016, pp.1–2, http://epostersonline.com/soa2016/node/860?view=true (2016, accessed 8 May 2018).
3. The Faculty of Intensive Care Medicine. Curriculum for Training for Advanced Critical Care Practitioners. London: FICM, 2015, pp. 1–40.
4. Health Education England. Multi-professional framework for advanced clinical practice in England, https://www.hee.nhs.uk/sites/default/files/documents/Multi-professional%20framework%20for%20advanced%

20clinical%20practice%20in%20England.pdf (2017, accessed 02 August 2018).
5. Boulanger C. The Advanced Critical Care Practitioner: trailblazing or Selling out? *J Intensive Care Soc* 2008; 9: 216–217.
6. University of Warwick. Advanced Critical Care Practice, pp.1–2, https://warwick.ac.uk/fac/med/study/cpd/critcare/cphc/ (2018, accessed 8 May 2018).
7. Coe AJ. AAGBI Safe vascular access guidelines I. *Anaesthesia* 2016; 71: 985.
8. Intensive Care Society. *Guidelines for the transport of the critically ill adult*. 3rd ed. London: ICS, 2011, pp.1–45..
9. Wong AV, Arora N, Olusanya O, et al. Insertion rates and complications of central lines in the UK population: a pilot study. *J Intensive Care Soc* 2018; 19: 19–25.
10. Registry NZEMN-ANZEDA. New Zealand Emergency Medicine Network-Australian New Zealand Emergency Department Airway Registry, pp.1–2, https://static1.squarespace.com/static/539106e6e4b020f43e5c2685/t/53f29d16e4b0d264691f3b45/1408408854250/Airway+Registry+NZEMN-ANZEDA-190814.pdf (2018, accessed 8 May 2018).
11. Brass P, Hellmich M, Kolodziej L, et al. Ultrasound guidance versus anatomical landmarks for internal jugular vein catheterization. *Cochrane Database Syst Rev* 2015; 1: CD006962.
12. Brass P, Hellmich M, Kolodziej L, et al. Ultrasound guidance versus anatomical landmarks for subclavian or femoral vein catheterization. *Cochrane Database Syst Rev* 2015; 1: CD011447.
13. Lathey RK, Lathey RK, Jackson RE, et al. A multicentre snapshot study of the incidence of serious procedural complications secondary to central venous catheterisation. *Wiley Online Lib* 2016; 72: 328–334.
14. National Institute for Clinical Excellence. Chapter 34: Standardised systems of care for intra- and inter-hospital transfers (Draft for consultation). pp.1–48, www.nice.org.uk/guidance/ng94/documents/draft-guideline-34 (2017).
15. Easby J, Clarke F, Bonner S, et al. Secondary interhospital transfers of critically ill patients: completing the audit cycle. *Br J Anaesth* 2002; 89: 349–367.
16. Ligtenberg JJM, Arnold LG, Stienstra Y, et al. Quality of interhospital transport of critically ill patients: a prospective audit. *Crit Care* 2005; 9: R446–R451.
17. Sakles JC, Chiu S, Mosier J, et al. The importance of first pass success when performing orotracheal intubation in the emergency department. *Acad Emerg Med* 2013; 20: 71–78.
18. Society TRCOAATDA. Major complications of airway management in the United Kingdom. In: Tim Cook, Nick Woodall, Chris Frerk (Eds.), 4th *National audit project of The Royal College of Anaesthetists and The Difficult Airway Society*. London: The Royal College of Anaesthetists, 2011.
19. Park LJ, Brainard A, and Zeng I. 105 A systematic review and meta-analysis of first pass success rates in emergency department intubations: creating a benchmark for quality emergency airway care. *Ann Emerg Med* 2015; 66: S37.
20. Edmunds C, Robinson O and Scott I. The introduction of an airway registry in a Scottish Intensive Care Unit (ICU) can it improve standards? pp.1–6, https://www.smacc.net.au/wp-content/uploads/2018/07/The-introduction-of-an-airway-registry-in-a-scottish-ICU-can-it-improve-standards.pdf (2018, accessed 8 May 2018)..
21. Stevenson AGM, Graham CA, Hall R, et al. Tracheal intubation in the emergency department: the Scottish district hospital perspective. *Emerg Med J* 2007; 24: 394–397.
22. Claxton A, Erinle T, Millar H, et al. Making Intubation Safer Together — a cross specialty program to improve the safety of out of theatre intubation | ICS State of the Art Meeting 2017, pp.1, http://epostersonline.com/soa2017/node/1432?view=true (2017, accessed 8 May 2018).
23. Simpson GD, and Ross MJ. Tracheal intubation in the critically ill: a multi-centre national study of practice and complications. *Br J Anaesth* 2012; 108: 792–799.
24. Higgs A, McGrath BA, Goddard C, et al. Guidelines for the management of tracheal intubation in critically ill adults. *Elsevier* 2018; 120: 323–352.
25. Higgs A, Cook TM, and McGrath BA. Airway management in the critically ill: the same, but different. *Br J Anaesth* 2016; 117: i5–i9.
26. Higgs A, McGrath BA, Goddard C, et al. Guidelines for the management of tracheal intubation in critically ill adults. *Br J Anaesth* 2018; 120: 323–352.