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'It's learned on the job and it depends who you're with.' An observational qualitative study of how internal jugular cannulation is taught and learned

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Abstract

Internal jugular cannulation may lead to serious complications. Ultrasound guidance is advocated; however, procedural complications remain a concern. Inconsistent education may be in part responsible for this. This study examined how internal jugular cannulation is taught and learned. An ethnographic approach was used in two acute hospitals. Methods comprised interviews, observations and focus groups. An inductive thematic analysis was undertaken. Three themes were identified: *apprenticeship*, *trust* and *reciprocity*. In *apprenticeship*, a new form of apprenticeship learning, necessitated by the structure of training is described. In *trust* the strategies by which trainers assess trainees' competence in order to allow them to gain experience is explored. In *reciprocity* the beneficial influence of trainees is illustrated. This study demonstrates how high-stakes procedures are learned. It provides insights into under-investigated topics such as the use of 'permitted mistakes' to stimulate reflection and the role played by trainees in promoting good practice.

Keywords

Internal jugular cannulation, ultrasound, medical education, apprenticeship, patient safety

Introduction

Ultrasound-guided (USG) central venous cannulation was pioneered by Yonei et al.,[1] who in 1986 reported a case series of 160 internal jugular vein (IJV) cannulations without complication. IJV cannulation went on to become the first procedure which was commonly USG; likely due to a combination of a growing evidence base which suggested a lower complication rate, and clinical guidelines advocating ultrasound guidance in the elective and emergency setting.[2,3]

The degree to which the safety benefits of ultrasound guidance translate to clinical practice is unclear, with some investigators finding no change, or even an increase in complications following its introduction.[4,5] Hypotheses for such counter-intuitive findings include that the introduction of ultrasound guidance has changed a tactile skill into a composite skill involving the integration of visual and tactile elements, and the development of education may not have kept pace with that of technology. Furthermore, in our prior publication from this project we observed that a more liberal approach to needle angulation appears to occur in the context of ultrasound guidance.[6] A recent multicentre study of procedural complications indicated a 3.1% incidence of 'significant complications', the most common of which was procedural failure.[7] The complications of central venous catheterisation represent a substantial contribution to litigation in critical care and anaesthetic practice.[8,9] As a result of these continuing concerns, the first Intensive Care National Audit Project (ICNAP-1) will focus on the insertion and early complications of central venous catheters.[10]

The requirement to be competent in central line insertion is present in the curricula for both intensive care medicine and anaesthesia,[11,12] and the recent AAGBI guideline on *Safe Vascular Access* recognises the importance of education and training in delivering a safe service.[13] However, the mechanism by which education does (or should) occur is not further described in these documents. We hypothesised that

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learning would largely take place in the workplace through a system of apprenticeship.

Collins' *Theory of Cognitive Apprenticeship* describes the process by which skills are transferred from 'master' to 'apprentice'. The first stage is *modelling* whereby the master carries out a task observed by the apprentice. This is followed by *coaching* where the apprentice performs the task under the observation of the master, who offers feedback and *scaffolding* where the master supports the development of independent practice.[14] Progression is facilitated through the strategies of *Articulation* (the apprentice answering questions or providing explanations of their reasoning), *Reflection* ('replaying' performances) and *Exploration* (encouraging independent problem-solving by *fading* the level of support that the expert provides).[14]

This manuscript reports the educational findings from a broader project concerned with the practice of USG IJV cannulation in anaesthesia and critical care.[6] The project as a whole was based on ethnography: the study of practice within its culture and environment through observation and discussion.[15,16] The research question which is addressed in this paper is 'how is USG IJV cannulation taught and learned?'

Materials and methods

The study was undertaken in two teaching hospitals in the North of England between July and October 2013. Hospital 1 has approximately 400 beds. Hospital 2 has approximately 800 beds, including a large cardiothoracic surgery unit. As a result of its larger size and specialist services, substantially more IJV cannulations are undertaken at Hospital 2. Approvals were obtained from the research and development departments of the participating hospitals and the Lancaster University Faculty of Health and Medicine Ethics Committee (IRAS 131693, ethics committee reference number not issued).

Data collection in each department commenced with semi-structured interviews with the consultants responsible for management (e.g. clinical director) and for training (e.g. faculty/college tutor). In Hospital 1 the departments comprised anaesthesia and critical care; In Hospital 2 the departments comprised anaesthesia, critical care and cardiothoracics (including cardiothoracic theatres and intensive care). This was followed by observation of IJV cannulations, sampled using a maximum variation strategy to observe a variety of clinical settings, grades of operator, times of day and degrees of clinical urgency. The data collection concluded with focus groups to which all study participants were invited. All observations and interviews were undertaken by the same researcher (CS), an academic anaesthetic trainee familiar with the procedure and settings under study.

Data were collected by way of audio recording (interviews and focus groups) and field notes (interviews, focus groups and observations). These were transcribed at the earliest convenience. Names were replaced with anonymised identifiers (e.g. 'Consultant 1 (C1)') and the originals were then confidentially destroyed. The anonymised transcripts were imported into Atlas.ti version 7 (Atlas.ti Scientific Software Development GmbH, Berlin) for coding. Data were then analysed using Braun and Clarke's method of thematic analysis, as described in our prior publication from this project.[6,17] A reflective journal was maintained by CS, and this combined with regular discussion with the multidisciplinary supervisors of the project in which assumptions could be challenged, facilitated a reflexive approach to the data. A participant validation meeting was conducted after the initial analysis, at which no suggestions for amendments were made.

Results

Twenty-seven clinical episodes were observed, in which 39 IJV cannulations were attempted. Nine observations were in cardiothoracics, in which two cannulae are often inserted, 14 were in operating theatres, and four in critical care. The main operator was a consultant in 16 observations and a trainee in 11 observations. Four observations occurred in Hospital 1, and 23 took place in Hospital 2. In 24 observations ultrasound guidance was used as the primary method for locating the IJV, in the remaining three the landmark technique was used, though in one case this was abandoned and converted to ultrasound guidance.

Three themes relating to the teaching and learning of IJV cannulation were generated from the data: *apprenticeship*, *trust* and *reciprocity*.

Apprenticeship

The NICE guidelines (2002) recommending that elective internal jugular cannulations should be USG was stated to be the major impetus for those who were in practice at this time to acquire the skill.[2] Early training in USG IJV cannulation was not apprenticeship based as 'masters' were not yet present in clinical practice. Learning instead occurred through a combination of individual experimentation by practitioners and formal courses organised by ultrasound equipment manufacturers. Such courses were acknowledged as beneficial by participants, as they offered consistent expert teaching, rather than passing-on practice without quality control:

> T8: I think it [the course] told me what you're actually supposed to do rather than what everybody does. They very much went on about always seeing the end of your needle, whereas I think the way a lot of it's taught from people, they don't actually see the needle . . .
>
> **Excerpt 1**: Focus group, intensivists and anaesthetists, Hospital 1

Despite this advantage, as experience of USG IJV cannulation has increased amongst clinicians, the demand for short courses has waned to the extent that they are now rarely provided (no formal 'non-clinical' training in central venous cannulation was offered to trainees at either institution during the study period). Early adopters have instead become 'masters' who pass their skills on to trainees. This has left the training of USG IJV cannulation within the clinical workplace and apprenticeship has been restored as the primary learning method.

That USG IJV cannulation is learned through apprenticeship was recurrently verified by participants. The statement in Excerpt 2 that 'it depends who you're with' hints at the potential for variability within the version of apprenticeship experienced by trainees, who are apprenticed to multiple 'masters' due to the rotational nature of their training.

C19: 'there's no formal process for it. We don't send them on an ultrasound course. It's just learned . . . Like all of anaesthetics, it's learned on the job and it depends on who you're with.'

Excerpt 2: Introductory interview, educator, ITU. Hospital 1

The initial training of 'novice' trainees is characterised by demonstration and in-depth explanation. More experienced trainees are also taught by demonstration and explanation, particularly when new to a department. However in this context a degree of competence is assumed and explanation is economical; restricted to points of particular relevance. In Excerpt 3 a consultant illustrates a specific matter to an experienced trainee who has recently started his cardiothoracic module. The overall goal here is to define the standard for practice rather than teach from first principles.

C15: 'You mustn't do it like this': *she threads the dilator over the first guidewire and holds it perpendicular to the skin.* 'I've seen someone put it into the artery like that as Cliff can tell you.' (*Referring to a case that we discussed in the introductory interview*).

Excerpt 3: Observation, Consultant cardiac anaesthetist teaching trainee, Hospital 2

Following demonstration and explanation, learners progress to practical experience guided by instruction. Initially this instruction is point by point, but as experience increases, a passive form of supervision is seen in which the trainer remains immediately available but may offer little or no input. In Excerpt 4 two consultants are supervising an experienced trainee. In this observation the only active supervision occurs from the moment when the trainee scans the patient's neck to just after needling the vein. The unobtrusive nature of the supervision was enabled by the favourable anatomy of the IJV observable on the ultrasound screen. Nevertheless, the consultants watched the trainee's practice and there is a suggestion that Consultant 32 was critical of the trainee's steeply angled needle insertion; the metaphorical comparison of his technique to a World War II Luftwaffe 'Stuka' warplane carries negative connotations.

C32: *Walks to the head of the bed and looks at the ultrasound image.* 'That looks very visible, very do-able. No pressure, just keep the vein in the middle of the screen.'

T13: *Inserts the needle, adjacent to the ultrasound probe. The needle is almost vertical. The superficial wall of the vein can be seen to distort on the screen.*

C32: 'He's a Stuka man . . . he's a Stuka man. Approaches something like this:' *he holds his left index finger out horizontally* 'like this:' *he brings his right index finger to meet it perpendicularly.*

C33: 'Leave him alone.' *Said with dramatic mock concern.*

Excerpt 4: Observation, Consultant anaesthetists supervising trainee, Hospital 2

Ultrasound guidance offers the teacher an additional medium through which to observe the learners practice. As shown in Excerpt 4, a brief look at the ultrasound screen can predict procedural difficulties (or lack thereof), or as in Excerpt 5, identify that the proposed trajectory of needle insertion is suboptimal before starting the procedure. Prior to the introduction of ultrasound, IJV cannulation was largely tactile in nature, and a supervisor would have had less information about what their trainee was doing, or proposed to do.

C15: 'You see how that's round there?' *referring to the position of the ultrasound probe* 'Move it.'

T11: *Moves the probe anteriorly. The picture on the screen changes so the vein is lateral to the artery.*

C15: 'See? The vein's away from the artery.'

Excerpt 5: Observation, consultant cardiac anaesthetist supervising trainee, Hospital 2

The consultant in Excerpt 5 indicates an attention to the importance of *process*; however, there were instances of feedback instead being dominated by *outcome*. This is illustrated in Excerpt 6, in which a senior trainee is supervising a junior colleague. In this

scenario the junior initially inserts the needle lateral to the IJV and angulates it medially, in a trajectory that would transect the carotid artery if the vein were transfixed. Though the senior trainee identifies a hazard in the junior's technique, the subsequent success of the procedure leads her to praise the process she was criticising only seconds before. This observation offers an insight into how suboptimal techniques may become established.

T14: *withdraws the needle to just below the skin, aspirating, but gets no flashback. She then angles the needle 30 degrees medially with respect to the vertical in the transverse plane and advances it towards the vein. On-screen, the lateral wall of the vein buckles in and a bright dot is seen at the apex of the buckle.*

T15: 'You're heading straight for the artery.'
T14: *Just as T15 makes her warning remark, the buckling of the wall of the vein ceases as the needle passes into the lumen – dark venous-looking blood starts to fill the syringe.*
T15: 'Look at that!' *She seems pleased.*
T14: *detaches the syringe from the needle and reaches for the guide wire.*
T15: 'Just leave the needle alone, it only takes a millimeter . . .'
T14: *Threads the guide wire*
T15: 'ECG's fine.'
T14: *Removes the needle over the guide wire.*
T15: 'Beautifully done, you can do them all.'

Excerpt 6: Observation, senior trainee supervising junior, ITU, Hospital 2

Mistakes are sources for reflection and may be permitted by some supervisors for this purpose. However as articulated in Excerpt 7, the educational benefit must be balanced against the potential for harm. One instance was observed where it was clear that a supervisor was allowing a mistake for the purpose of learning: in Excerpt 8 the trainee has the patient's trolley at a height that is too low. Despite the trainee's obvious discomfort the consultant allows this to persist, only correcting it at the end of the procedure. In this 'permitted mistake' the trainee evidently suffered somewhat, but the patient did not appear to be placed at excess risk. This educational strategy appeared to be effective: in a subsequent observation involving the same trainee, one of his first actions was to optimise the height of the trolley.

C9: 'Do you not let the trainees make the mistakes? Because I do [C1: "Oh yeah, yes"] because they're always eager to crack on with it "I want to do it, I want to do it", so I . . .'
C1: (interrupts) 'It depends what time of night it is.' *This gets a laugh from the group*
C9: 'You're: "are you ok doing it?" And they're: "fine." And you watch them make the mistakes and, kind of, sit on your hands. [C29: *laughs*] and then talk about it afterwards.'
C29: 'I think that I need to start taking the pill that you take. [*both laugh*] my coronary arteries would be struggling with that process!'

Excerpt 7: Focus group, consultant anaesthetists and intensivists, Hospital 2

T16: *mutters under his breath as he stitches the hub* 'Aaah, feck . . . I hate these.' *He stretches his back.*

O11: 'Do you want the bed higher?'
T16: 'Every time I do this it canes [hurts] my back.'
C1: 'We'll put it up . . . show you how easy it would have been.'

Excerpt 8: Observation, Consultant anaesthetist supervising trainee, Hospital 2

In three cases of attempted IJV cannulation by trainee anaesthetists the procedure was unsuccessful. In all of these cases a more senior trainee took over and placed the cannula successfully. Failure appeared to stimulate intense reflection; in every case the trainee remained at the bedside to observe the subsequent procedure and discuss the reasons for their failure. The resulting debriefs were conducted in a sympathetic fashion by seniors; acknowledging and accounting for the emotional difficulty of procedural failure appeared to take precedence over the critique of practice.

This theme, *Apprenticeship* explores the process of workplace learning. The apprenticeship we observed differs from its Collins' model in that trainees move frequently from teacher to teacher, and this affects the educational relationship. This will be explored in the next theme: *trust*.

Trust

In the past, training involved longer hospital placements and trainee doctors worked longer hours. Under these circumstances the consultants in a department got to know their trainees well. More recently trainees have tended to remain in a department only until they had completed the required 'module' before rotating elsewhere. A phenomenon noted recurrently by cardiothoracic anaesthetists from Hospital 2. Due to the specialist nature of their department, trainees rotate frequently and as a result, consultants may meet each trainee only once. This places consultants in a predicament; the trainee requires clinical experience, but in order to permit this the consultant has to

trust that they are sufficiently competent to avoid putting the patient at risk (Excerpt 9):

C15: 'I think it's difficult these days 'cause the trainees are here for ten days or so and there's a lot of pressure on us to let them do practical things 'cause they've got their cardiac module which is really short and you feel like you have to let them do things. And you know, a few years ago it would have been quite nice to have someone all day, watching what you did all day, then you watch them very closely and then you work with them again, but you know in this day and age we'll work with someone once [C24: 'yep'] and you have to very quickly make an assessment: "am I going to let them do this?"'

Excerpt 9: Focus group, cardiac anaesthetists, Hospital 2

Though the images seen on the ultrasound screen make IJV cannulation more visible to the supervisor (Excerpts 4 and 5), trust remained a major concern. In the absence of the time in which to build trust in a trainee, consultants instead turn to surrogate measures. One strategy was a brief résumé of previous experience. Another involved assessing the trainee's performance at other procedures, and extrapolating this to predict their competence at IJV cannulation, as in excerpt 10 in which a consultant is supervising a senior trainee who has recently started his cardiothoracic module.

C15: *Whispers* 'I'm thinking I'll probably let him do the central line . . . he got the Venflon [peripheral venous cannula] straight in . . . the girl I was with the other day, I watched her mess up the Venflon, intubate the oesophagus . . . I thought "I'll get her to watch me." If he gets the A line in I'll let him do it. He is an ST5 . . . I'm thinking about this 'cause you're here. You do these things without thinking usually. You have to make a lot of judgments.'

T11: *inserts the arterial line on his first attempt. It looks like he's well practiced in the procedure.*

Excerpt 10: Observation, consultant cardiac anaesthetist supervising trainee, Hospital 2

The use of a trainee's seniority as a surrogate for their competence appears to have been involved in the consultant's decision-making process in Excerpt 10. However, this was insufficient on its own: permission to gain hands-on experience was contingent on his performance of arterial cannulation. Training grade was deemed to be misleading by some consultants who described being 'taken in' by trainees regardless of their seniority. This carries connotations of betrayal, though whether the betrayer is the trainee or the system in which they are trained is open to interpretation. Further evidence of the betrayal of trust is seen in Excerpt 11, in which a consultant describes being 'caught out' by trainees whose competence does not match their confidence, and his colleague describes taking the precaution of 'scrubbing in' to be in a position to immediately correct the practice of unknown trainees.

C31: '. . . it doesn't matter what grade though, I get recurrently caught out [C1: 'yeah'] by failing to adequately ask as to what their experience . . .'

C1: (interrupts) 'Oh, saying that, if I don't know them, the first time I will be scrubbed as well, in the process . . .'

Excerpt 11: focus group, consultant anaesthetists and intensivists, Hospital 2

This second theme *trust* illustrates the challenges that consultants experience in building trust in trainees on short-term rotations. Inaccurate assessment of competence can indirectly lead to patient harm, and difficulties in the educational supervision relationship.

Reciprocity

A substantial proportion of the teaching of trainee doctors is undertaken by trainees of a more senior grade (e.g. Excerpt 6). The teaching of juniors is presented by consultants as an opportunity for senior trainees, especially when they rotate to specialties in which they do not desire to work in the long term, for example anaesthetic trainees rotating to intensive care (Excerpt 12):

C25: 'If we've got, which we often have, um.. trainees who are doing their [higher] module.. who aren't necessarily intensivists by training, they've got to do a . . . a second six months of ITU to complete their competencies. It would be fair to say we get a lot of trainees who don't want to become intensivists who've got to get it signed off, they seem to like working here and something that we often do is turn around and go: "right you're around a lot, the new-starting trainee's around a lot. Expand your teaching role; start taking these people and teach them what's going on." Sort-of: "watch me do a couple, talk through what we've done."'

Excerpt 12: Introductory interview, manager, ITU, Hospital 1

Senior trainees acting as teachers appears to have benefits for both the senior and junior trainee, through offering the chance to develop teaching skills for the former, and offering a more consistent apprenticeship relationship for the latter as they are both 'around a lot' when training in the same department. A potential drawback with trainees teaching USG IJV cannulation is that both their clinical and teaching skills may be less developed than those of their consultant colleagues (e.g. excerpts 5 and 6).

Another context in which trainees act as teachers is in educating their consultant colleagues; a reversal of the usual relationship. The most notable role of this inverted teaching relationship was the introduction of new techniques or practices learned at other hospitals: trainees who had used ultrasound guidance at other institutions were described as a cofactor for its adoption following the publication of the NICE guideline.[2] Although ultrasound guidance is now universally available, as described in Excerpt 13, trainees have continued to act as educators to their senior colleagues by expanding the role of ultrasound guidance. In this respect the rotational nature of training was perceived as beneficial by the consultants.

C15: '. . . Another thing that is a slightly different area is using ultrasound to put in subclavian central lines which is something that people do less commonly here. Umm, and that's actually an area where trainees have actually been . . . Teaching some of us recently [*laughs*]. So that's a kind-of new experience but we're probably not as expert at using ultrasound for subclavian lines as other places.'

CS: 'Is that something you come across from time-to-time, that trainees moving through the department bring new skills?'

C15: 'Yeah that's quite nice, cause you do.. when you move around you learn new things, don't you? So it's a two way thing; as well as them learning from us we learn from them as well, so it's quite nice.'

Excerpt 13: Introductory interview 7, manager, cardiac anaesthesia, Hospital 2

A form of peer review, comparing practice to that of other institutions is demonstrated in Excerpt 14, in which a trainee and a consultant are setting up the equipment for IJV cannulation. In this observation the trainee identifies that the contents of the central line 'pack' in Hospital 1 are inconsistent with practice at other institutions in which she has worked and proposes to undertake a project ('a thing') to compare the costs and benefits of the practice at her current institution with elsewhere. The willingness to critique institutional practices demonstrated by the trainee and the openness to change shown by the consultant provide an insight into the mechanism by which trainees act as catalysts for change in practice through their reciprocal relationship with their consultants.

T8: 'I thought they'd be in the pack.' *She enters the bay, holding saline and syringes, and opens them onto the drape.* 'What is in the pack?'

C21: 'This, this and this.' *I can't see exactly what he points to– I think it is a fenestrated drape, some gauze swabs and a green drape.*

T8: 'Why don't you have a pack with everything in?'

C21: 'Cost.'

T8: 'Everywhere else does . . . Should I do a thing . . .? To look at how much doctor and nurse time is wasted?'

C21: 'That'd be good.'

Excerpt 14: Observation 14 – trainee assisting consultant, ITU, Hospital 1

The third theme, *reciprocity* has explored two ways in which trainees act as trainers: in teaching junior colleagues and introducing consultants to new practices. The rotation system offers a form of peer review for each participating institution, offering a mechanism by which institutions can learn from trainees.

Discussion

The structural features of Collins' *Theory of Cognitive Apprenticeship* (*modelling, coaching and scaffolding*) are evident in our study.[14] However, the presence of multiple 'masters' for each apprentice, as articulated in Excerpt 2, causes the process to be modified as seen in Excerpt 3 in which a learner is exposed to additional *modelling* on moving to a new rotation.

Permitting mistakes in order to provide vivid material for *reflection* appears to be taboo in the medical education literature, and references to it are found only in papers which advocate the use of simulation in order to allow mistakes in a 'safe space'.[18–20] Such papers are critical of allowing mistakes in real practice and do not discuss the scope or nature of mistakes that could be allowed. It is easy to see why authors are reluctant to explore this topic – 'promoting' medical error for the purposes of training would be potentially controversial. The available literature on the value of mistakes therefore lies in the simulation context, and the *Best Evidence in Medical Education* review of high-fidelity simulation found that allowing and learning from mistakes in a controlled environment is a key feature of simulator-based learning.[21] It appears that a similar strategy is employed in the real-life setting. The consultants interviewed in this study describe 'sitting on their hands', preventing themselves from intervening in certain circumstances

1. Attributes of the trainee (e.g. tired, confident, level of training).
2. Attributes of the supervisors (e.g. lenient or strict).
3. Context (e.g. time of day, facilities available).
4. The nature of the EPA (e.g. rare, complex versus common, easy).

Figure 1. ten Cate's variables of entrustment decisions.[27]

(Excerpt 7). In the instance when this strategy was observed the patient was not exposed to additional risk (Excerpt 8). This can be contrasted to the swift correction of a potentially safety-critical error in Excerpt 5. It therefore appears from our data that teachers make a risk assessment of each unfolding mistake, aiming to allow 'safe' mistakes.

Training in ultrasound guidance for IJV cannulation at the time of its introduction was undertaken through short formal courses and/or individual experimentation. This 'trial-and-error' approach to experiential learning forms part of Kolb's well-known *Experiential Learning Cycle*.[22] The necessity for self-directed learning has been described in other settings when new technology disrupts the apprenticeship model because insufficient 'masters' exist to pass knowledge on.[23,24] Aggarwal et al.[25] argue that this creates a mandate for simulation-based training where new technologies are concerned. In 1993, nine years before the NICE guidelines on USG IJV cannulation were published, the *Advisory Council on Science and Technology* (ACOST)[26] published recommendations on the introduction of innovations, stating that 'specific centres specialising in appropriate diseases and techniques should be resourced to develop, evaluate and educate the rest of the profession'. The data from this study suggest that this recommendation was not followed in the case of USG IJV cannulation.

The role of trust between a supervisor and a trainee has been explored in the medical literature. ten Cate[27] states that entrustment decisions are influenced by four dynamic variables (Figure 1). There are data to support this in this study, in which trainees were trusted less on moving to a new institution or working with a new consultant (Excerpts 9, 10 and 11), and trusted more when the procedure appeared to be straightforward (Excerpt 4). Hauer et al.[28] expand ten Cate's work by proposing the basis on which trust is built: observation, comparison with a standard and stakeholder input, for example from patients or other team members. In the setting of IJV cannulation however, these strategies are not always practical: the high-stakes nature of the procedure means that supervisors need to trust the trainee *before* the procedure begins so observation of practice may be too late. This study documents a number of albeit imperfect strategies that are used by supervisors to determine trustworthiness in this high-stakes setting, providing an insight into an important facet of educational decision-making in the critical care environment.

The role of senior trainees in teaching their junior colleagues has a long history in medical training. This 'near-peer' learning model has been found to have benefits for both learner and teacher, who has the opportunity to develop educational skills at an early stage.[29–31] The transmission of good practice from one institution to another by medical trainees on rotation is less well recognised in the medical literature. However, a review by Greenhalgh et al.[32] identified four key roles played by personnel in the introduction of innovations to healthcare organisations: *opinion leaders, change agents, champions* and *boundary-spanners*. Trainees span institutional boundaries due to their training rotations, and therefore organisations that host trainees have enhanced links to the outside world. Greenhalgh et al.[32] argue that this 'institutional cosmopolitanism' is theoretically linked to increased receptiveness to innovation. Trainees also appear to act as *champions*, advocating for the good practice that they have witnessed elsewhere and even teaching it to consultants in their new hospitals (Excerpts 13 and 14).

Strengths and weaknesses

Ethnographic methodology presents some limitations. It is focussed on depth of understanding rather that breadth, and this study may therefore have limited generalisability in other contexts. International readers, for example, may work within very different systems of medical training to that of the UK doctors described in this study. Likewise because of the relative rarity and unpredictable nature of serious mechanical complications ethnography is not well equipped to investigate these as the sample size is necessarily small.[7] However, the methodology we employed allows concepts to be explored that would be impossible to capture using more traditionally 'biomedical' methods.[33,34] Qualitative studies have the ability to explain why some of the findings of their quantitative counterparts may be observed, and we hope that our work will be of particular use as the critical care community prepares to collect nationwide data on central line practice and safety.[10]

Recommendations for research and practice

Future research should focus on concepts which have been seen in this study, but which remain incompletely understood. This includes 'permitted mistakes', which appear to be more prevalent than the

existing literature would suggest. Of specific interest would be to investigate the point at which the supervisor should intervene. Another key area for future research is the assessment of trustworthiness, which appears to be inadequately accomplished by the existing training system. Despite having developed a number of coping strategies, the potential to be 'caught out' remains and it is therefore in the interests of teachers, learners and patients to further investigate trust in the high-stakes setting.

A number of recommendations for educational practice can also be made: this study suggests that formal courses address some of the pitfalls of the apprenticeship process, and institutions should support the introduction of potentially beneficial new technologies by offering an adequate training as recommended in the ACOST report.[26] Simulation offers an attractive opportunity here because it safely harnesses the learning potential of mistakes and can support skill development through deliberate practice.[21] However, without major organisational change the teaching and learning of internal jugular cannulation will remain in the workplace, and clinical educators should follow similar principles of maintaining patient safety, paying attention to process rather than simply focusing on outcome and providing constructive feedback to stimulate reflection. There are currently an expanding number of educational courses available to clinicians, and such training is becoming more common for non-educationalists.[35] This study demonstrates some of the potential impacts that an enhanced understanding of clinical education may offer to both trainers and trainees. Finally, the role played by trainees in maintaining and improving the standard of care should be acknowledged and harnessed. At present, trainees may be transferred away from poorly performing clinical departments.[36,37] However, this study illustrates how the presence of trainees leads to transfer of good practice between institutions, and local education and training boards should therefore carefully consider the implications of such an action on patient care.

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