DEPARTMENT OF ANESTHESIOLOGY

JOURNAL CLUB

Tuesday May 19, 2015
1800 HOURS

LOCATION:
Curry Original
253A Ontario Street, Kingston

PRESENTING ARTICLES:
Dr. Mike Cummings & Dr. James Cheng

SUGGESTED GUIDELINES FOR CRITICAL APPRAISAL OF PAPERS
ANESTHESIOLOGY JOURNAL CLUB
QUEEN'S UNIVERSITY

Two presenters will be assigned to choose and present summaries of their papers. Ideally the two papers will represent similar topics but contrasting research methodologies. The focus remains on critical appraisal of the research and manuscript, more than on the actual contents of the article. Each presenter will then lead an open discussion about the article, based around the guidelines below. The object is to open up the appraisal to wide discussion involving all participants, who will be expected to contribute pending suspension of bar privileges.

GENERAL

1. Title of paper: Does it seem like an important problem? Does it reflect the purpose/results?
2. Authors, institution and country of origin

INTRODUCTION

1. What is the problem being addressed?
2. What is the current state of knowledge of the problem studied?
3. What is the hypothesis being tested?
4. How does testing the hypothesis help solve the stated problem?

METHODOLOGY

1. Study design:
    a) Clinical trial vs. systematic review/meta-analysis
    b) Prospective vs. retrospective
    c) Observational vs. Experimental
    d) Randomized or not
    e) Blinded or not

2. Population studied:
    a) Human, animal, other
    b) Justification
    c) Control groups: experimental vs. historical
    d) Is the sample size/power calculated, and how?
    e) Is the population similar to your own practice?
    f) Single vs. multi-centre

3. Is the study ethically sound?
    a) Clinical equipoise
    b) Does treatment meet standard of care (esp controls)?
    c) Appropriate consent and institutional ethics approval

4. Exclusions: what groups are excluded and why?

5. Experimental protocol
    a) Is it designed to test the hypothesis?
    b) Is it detailed enough to be reproducible?
    c) Is the methodology validated?
    d) Are the drugs/equipment used detailed?
    e) How does the randomization take place?

6. What are the primary endpoints?
7. Is power sufficient to justify secondary endpoints?
8. Is the protocol clinically relevant?
9. Data collection and analysis
10. Statistical analysis: Is it appropriate? Are results

RESULTS

1. Are the groups comparable?
2. Were any subjects/data eliminated?
3. Analyzed by intent to treat?
4. Are adequate details of results provided? - data, graphs, tables

DISCUSSION

1. What is the main conclusion of the study?
2. Do the results support this conclusion?
3. Do the results address the stated purpose/hypothesis of the study?
4. How do the authors explain the results obtained?
5. Are there any alternative interpretations to the data?
6. Are the results clinically as well statistically relevant?
7. How do the results compare with those of previous studies?
8. What do the results add to the existing literature?
9. What are the limitations of the methods or analysis used?
10. What are the unanswered questions for future work?

APPLICABILITY OF THE PAPER

1. Have you learned something important from reading this paper?
2. Will the results of this study alter your clinical practice?
3. Was the food and wine up to the high standards expected by self-respecting anesthesiologists?

Journal of Clinical Anesthesia (2015) **27**, 237–242

ELSEVIER

Journal of Clinical Anesthesia

Original Contribution

Is there a dose response of dexamethasone as adjuvant for supraclavicular brachial plexus nerve block? A prospective randomized double-blinded clinical study☆

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Received 11 May 2014; revised 24 October 2014; accepted 29 December 2014

Keywords:
Adjuvant;
Analgesia duration;
Brachial plexus nerve block;
Dexamethasone;
Dose response

Abstract

Study objective: The study objective is to examine the analgesic effect of 3 doses of dexamethasone in combination with low concentration local anesthetics to determine the lowest effective dose of dexamethasone for use as an adjuvant in supraclavicular brachial plexus nerve block.

Design: The design is a prospective randomized double-blinded clinical study.

Setting: The setting is an academic medical center.

Patients: The patients are 89 adult patients scheduled for shoulder arthroscopy.

Interventions: All patients were randomly assigned into 1 of 4 treatment groups: (i) bupivacaine, 0.25% 30 mL; (ii) bupivacaine, 0.25% 30 mL with 1-mg preservative-free dexamethasone; (iii) bupivacaine, 0.25% 30 mL with 2-mg preservative-free dexamethasone; and (iv) bupivacaine, 0.25% 30 mL with 4-mg preservative-free dexamethasone. All patients received ultrasound-guided supraclavicular brachial plexus nerve blocks and general anesthesia.

☆ Disclosures: The study was supported by departmental fund to JL at the University of Pennsylvania (Philadelphia, PA). The authors declare no conflict of interest.
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http://dx.doi.org/10.1016/j.jclinane.2014.12.004

Measurements: The measurements are the duration of analgesia and motor block.
Main results: The median analgesia duration of supraclavicular brachial plexus nerve block with 0.25% bupivacaine was 12.1 hours; and 1-, 2-, or 4-mg dexamethasone significantly prolonged the analgesia duration to 22.3, 23.3, and 21.2 hours, respectively (P = .0105). Dexamethasone also significantly extended the duration of motor nerve block in a similar trend (P = .0247).
Conclusion: Low-dose dexamethasone (1-2 mg) prolongs analgesia duration and motor blockade to the similar extent as 4-mg dexamethasone when added to 0.25% bupivacaine for supraclavicular brachial plexus nerve block.

1. Introduction

Perioperative pain management is an important and challenging task in clinical practice. It is closely related to surgical outcome and patient satisfaction. Regional anesthesia, via either single-injection or continuous catheter infusion, may improve the quality of perioperative pain management.

The single-injection nerve block is easier to perform and requires fewer resources in follow-up management. However, solitary nerve block is limited by the duration of action. Finding pharmacologic adjuvants to the local anesthetic that could reliably prolong the analgesia effect has been the focus of researchers recently. One promising adjuvant is dexamethasone. Several studies have reported that 8 mg of dexamethasone may significantly prolong the analgesia duration of brachial plexus nerve block in combination with various local anesthetics, including lidocaine, mepivacaine, ropivacaine, and bupivacaine [1-5]. Furthermore, Tandoc et al [4] reported similar duration of analgesia and motor blockade with 4-mg and 8-mg dexamethasone.

A detailed review of these studies drew the following conclusions. First, dexamethasone significantly prolongs the duration of analgesia. Second, most studies show that dexamethasone prolongs motor blockade longer than analgesia duration when combined with a high concentration of local anesthetics [1-5]. Although these studies quite convincingly show that dexamethasone is an effective adjuvant in prolonging analgesia when used along with high concentrations of local anesthetics, it remains unclear if dexamethasone when combined with lower concentration of local anesthetics will provide the desired benefit of pain relief, while minimizing the undesirable motor impairment [1-5]. Previous researchers have shown that lower concentrations of local anesthetic are equally effective in achieving perioperative pain management with a duration of action comparable with higher concentrations [6]. The potential synergistic effect of dexamethasone with lower concentration local anesthetics is unclear.

Dexamethasone is a Food and Drug Administration–approved antiinflammatory steroid that has been widely used in anesthesia practice for postoperative nausea and vomiting prophylaxis and for its antiinflammatory effect. Methylprednisolone is probably the first steroid used as local anesthetic adjuvant in peripheral nerve block [7]. The use of dexamethasone as an adjuvant to local anesthetic in humans was first reported in 2003 [8]. There has been no neuronal injury reported in all in vivo studies [1-5]. However, the sample sizes of these studies are relatively small. Williams et al [9] reported potential neurotoxicity of dexamethasone on rat neuron in vitro. The potential neuronal toxicity of perineural-deposited dexamethasone in humans is worrisome, especially at higher doses. The lowest effective dose of dexamethasone as an adjuvant for nerve block remains unknown. The dexamethasone 4 mg/mL preparation used in these studies may not be preservative free, at least in the United States. The potential clinically significant neuronal toxicity from the preservative awaits further investigation.

A double-blinded clinical study was performed to evaluate the analgesic effect of 3 lower doses of dexamethasone in combination with low concentration local anesthetics to determine the lowest effective dose of dexamethasone for use as an adjuvant in peripheral nerve block. It was hypothesized that lower dose of dexamethasone as adjuvant also significantly prolongs the duration of bupivacaine analgesia for supraclavicular brachial plexus nerve block.

2. Materials and methods

2.1. Patients and study design

The University of Pennsylvania Institutional Review Board approved the clinical study, including the use of preservative-free dexamethasone. The study was registered at www.clinicaltrials.gov (identifier no. NCT01690663). We recruited patients who were undergoing shoulder arthroscopy at Presbyterian Medical Center of the University of Pennsylvania, PA. For the purpose of sample size calculation, a clinically significant difference of analgesia duration was determined as 3 hours' difference. Based on previous study [4] with estimated average duration of analgesia at 22 hours with dexamethasone in 0.5% bupivacaine and assumed average SD of 3 hours, we estimated that 16 patients would be needed to provide 80% power to conclude absence of effect at the significance level of 0.05 among treatment groups [10]. To allow for 20% patient dropouts, 20 subjects

per group were targeted to be enrolled. All consented patients were randomly assigned into 1 of 4 groups: (i) bupivacaine, 0.25% 30 mL; (ii) bupivacaine, 0.25% 30 mL with 1-mg preservative-free dexamethasone; (iii) bupivacaine, 0.25% 30 mL with 2-mg preservative-free dexamethasone; and (iv) bupivacaine, 0.25% 30 mL with 4-mg preservative-free dexamethasone. All patient assignments were guided by computer-generated randomization table and individually sealed envelope. The participating anesthesia residents who also completed the documentation for the nerve block prepared the medication. Patients, attending anesthesiologists, and research assistant collecting the data were all blinded of the group assignment.

The inclusion criteria were patients between ages of 18 and 75 years old scheduled for primary shoulder arthroscopic procedure. All patients were eligible for and had already elected to receive regional anesthesia before consenting for the study. All patients must have had a valid phone number and be able to speak, read, and write in English for follow-up purpose. Exclusion criteria included patients with severe lung disease, contralateral phrenic nerve injury, insulin-dependent diabetes, hepatic disease/failure, kidney disease/failure, pregnancy, chronic opioid use (defined as opioid use >3 months), or allergy to any of the study medications.

The study was conducted between September 2012 and October 2013. There were 97 patients evaluated for eligibility, and, eventually, 89 patients were enrolled into the study. There were 76 patients with complete primary outcome data collected. There was 1 patient with failed nerve block as determined by intraoperative response and immediate postoperative evaluation. There were also 12 patients who could not complete the first follow-up inquiry by the end of postoperative day 2, and, thus, postoperative data were missing. Intent-to-treat analysis on all 89 patients was conducted to minimizing sampling bias.

2.2. The standard of care anesthesia regimen

All single-shot supraclavicular brachial plexus nerve blocks were performed in the preoperative holding area with standard American Society of Anesthesiologists (ASA) monitoring by residents under the direct supervision of 1 of 3 attending regional anesthesiologists. Typically, patients received 1-2 mg of midazolam and 50-100 μg of fentanyl for sedation during the placement of the block. Standard operating procedure of the block room was followed. Ultrasound-guided block was performed within plane lateral approach. The view of brachial plexus nerve block was consistent among all 3 attending anesthesiologists. Upon adequate visualization of the supraclavicular brachial plexus, the ultrasound probe was shifted cephalic to achieve the final ultrasound view that there was clear separation between subclavian artery and the brachial plexus. Bupivacaine 0.25% without or with various amount of preservative-free dexamethasone (1, 2, or 4 mg) were injected around the brachial plexus with 2-in Stimuplex needle (B Braun, Melsungen, Germany). All patients then received standard general anesthesia in the operating room. General anesthesia was induced using propofol, fentanyl, and vecuronium to facilitate tracheal intubation and maintain muscle relaxation during the procedure. Maintenance of anesthesia was with sevoflurane in oxygen/air mixture. Intraoperative narcotic usage was left to the discretion of operating room anesthesiologists, whereas long-acting narcotics were discouraged. All postanesthesia care unit (PACU) analgesia followed a standard of care protocol for postoperative care with fentanyl, 25 μg intravenous every 5 minutes as needed and/or hydromorphone, 0.2 mg intravenous every 5 minutes as needed and/or oxycodone/acetaminophen, 5/325 mg 1-2 tablets orally every 3-4 hours as needed. All patients were subsequently discharged home with oxycodone/acetaminophen 5/325 orally every 4-6 hours as needed.

2.3. Data collection

Patients' demographic information was collected, including age, sex, body mass index (BMI), ASA status, surgical procedure, and surgical time. All patients were interviewed over the phone on postoperative day 1, day 2, and/or day 7. The primary outcomes were the time of analgesia duration (defined as the onset of sensory discomfort that required medication) and time of motor recovery (defined as the recovery of full motor function of both wrist and elbow on the nerve block side).

2.4. Statistical analysis

The statistical analysis was performed in STATA 12.1 statistical software (StataCorp LP, College Station, TX). Data were expressed as mean ± SD or median with interquartile range as appropriate. Categorical data were analyzed with Fisher exact test and chi-square test. The duration of analgesia and motor block was analyzed by the Kaplan-Meier survival analysis and Cox proportional hazards modeling. Subgroup pairwise analyses were conducted via Kruskal-Wallis rank test with Bonferroni correction for significance. All analysis was conducted with intent-to-treat approach to minimize the potential effects of dropout. Statistical significance was defined as $P < .05$.

3. Results

Ninety-seven patients were assessed for eligibility of the study, and 89 patients were enrolled and randomized into 4 treatment groups (Fig. 1). There were total of 12 patients with missing data and 1 failed block. There was 1 patient who had transit paresthesia through postoperative day 2. The patient received bupivacaine 0.25% 30 mL with 2-mg

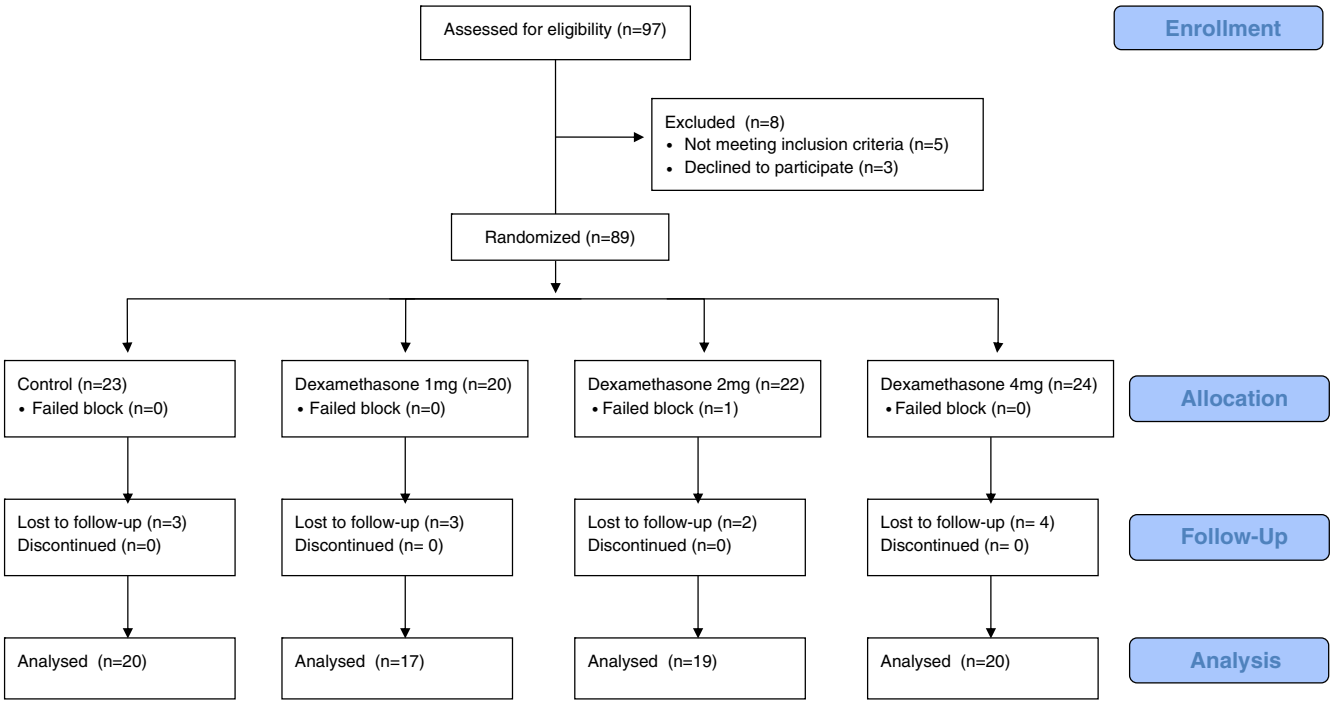

Fig. 1 Consort diagram for study enrollment.

preservative-free dexamethasone. The brachial plexus nerve block was performed routinely using ultrasound guidance without any incidence. The surgical procedure was debridement without any reported surgical complications. However, the patient reported tingling and some burning sensation of the surgical arm on evening of postoperative day 1. There were no hospital workups performed, including electromyography study at that time per primary surgical team. The symptoms resolved completely in the morning of postoperative day 3. There were no other complications among all study patients. All patient demographic information was summarized in Table 1. All groups were comparable in age, BMI, sex, ASA status, ethnicity, types of surgical procedure, and duration of surgery.

There were no statistically significant differences in intraoperative opioid use, PACU pain score, PACU opioid use, and PACU length of stay (Table 2). The median analgesia duration of control plain 0.25% bupivacaine was 12.1 hours; and additional 1-, 2-, and 4-mg dexamethasone significantly prolonged the analgesia duration to 22.3, 23.3, and 21.2 hours, respectively (Fig. 2, Table 2; $P = .0105$). There were no significant differences in analgesia duration among various dexamethasone dosage groups ($P > .05$). Dexamethasone also significantly extended the duration of motor nerve block in a similar trend (Fig. 2, Table 2; $P = .0247$). The median duration of motor block with 0.25% bupivacaine was shorter than the analgesia duration across all study groups. All treatment groups had comparable patient satisfaction (Table 2; $P = .825$).

Table 1 Patient demographic information

		Control group	Group 1-mg dex	Group 2-mg dex	Group 4-mg dex
Age (y)		47.1 ± 11.3	46.2 ± 11.8	48.8 ± 14.1	53.0 ± 12.5
BMI (kg/m^2)		30.4 ± 6.6	29.4 ± 4.0	28.9 ± 4.4	31.0 ± 6.3
Sex (M/F)		18/5	14/6	16/6	19/5
ASA classification (I/II/III)		9/13/1	7/8/5	5/16/1	3/17/4
Ethnicity (C/A/O)		17/5/1	15/5/0	15/7/0	12/12/0
Procedure	RC repair	13	10	10	12
	SLAP/Bankart repair	3	5	4	6
	Debridement/others	7	5	8	6
Intravenous dexamethasone (Y/N)		21/2	18/2	19/3	23/1
Duration of surgery (min)		80.2 ± 36.1	92.9 ± 31.4	90.0 ± 34.4	109.7 ± 50.1

Abbreviations: *dex*, dexamethasone; ethnicity: *C*, Caucasian; *A*, Africa American; *O*, others (include Hispanic, Asian, and etc); *RC*, rotator cuff; *SLAP*, superior labrum, anterior to posterior.
Data represent mean ± 1 SD.

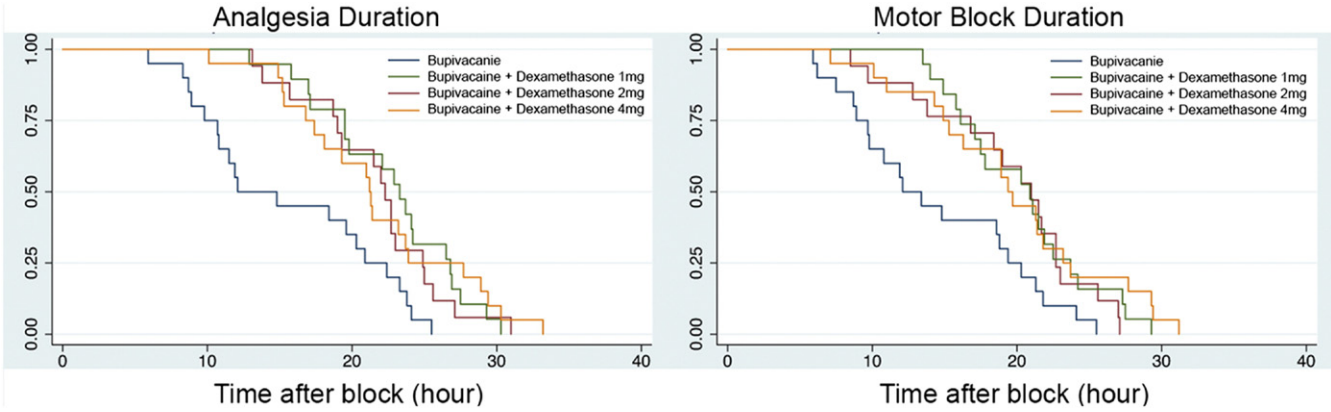

Fig. 2 Analgesia and motor block durations for 0.25% bupivacaine ± dexamethasone. Data represent Kaplan-Meier survival analysis.

4. Discussion

Dexamethasone significantly prolongs analgesia and motor block duration with 0.25% bupivacaine in supraclavicular brachial plexus nerve block. In addition, this study did not show statistically significant differences among different dosages of dexamethasone on analgesia duration and motor block prolongation. Vieira et al [5] studied effects of 20 mL 0.5% bupivacaine on interscalene brachial plexus block in combination with 8-mg dexamethasone and observed analgesia duration for 24.3 and 13.9 hours, respectively. Tandoc et al [4] conducted a similar study with 40 mL 0.5% bupivacaine and concluded that the duration of analgesia was significantly prolonged with 4-mg dexamethasone to 21.6 hours, 8-mg dexamethasone to 25.2 hours, with the control group at 13.3 hours.

Corticosteroids have been injected in combination with local anesthetics for peripheral nerves block in our clinical practice frequently. The addition of corticosteroids has shown benefits with prolonged duration of analgesia. We are not aware of other investigations into use of dexamethasone as an adjuvant to peripheral nerve blockade that state that preservative-free dexamethasone was used. All previous studies either acknowledged that dexamethasone contained preservatives or did not clarify the preservative-free nature of dexamethasone in the nerve block mixture. In addition, all previous studies used dexamethasone 4 mg/mL preparation, which contains preservatives, especially true in the United States. Previous publications indicate that the potential confounding variable of preservatives in the dexamethasone cannot be eliminated from their data. Our observation with the preservative-free dexamethasone clearly supports the effectiveness of dexamethasone alone in prolonging analgesic duration of brachial plexus nerve blockade.

We observed shorter motor block duration compared with analgesia duration. Previous studies reported conflicting results with 0.5% bupivacaine mixture. Vieira et al [5] observed shorter motor block duration than analgesia duration, 22.9 hours vs 24.3 hours. However, Tandoc et al [4] reported significant prolonged motor blockade over analgesia duration, 36.7 vs 21.6 hours with the 4-mg dexamethasone, and 39.2 vs 25.2 hours with the 8-mg dexamethasone in the block mixture. The significant differences in their observations on the motor block duration maybe were probably related to the method that the motor response was evaluated because shoulder immobilization due to surgical requirement might compromise the evaluation of the motor recovery evaluations. We selected 0.25% bupivacaine with the intention of less motor blockade. Our result is comparable with the study of Vieira et al [5]. In addition, we defined the motor block recovery time as the time of recovery in motor function of both elbow and wrist after the nerve block. We avoided evaluation of shoulder movement as the indicator for motor recovery because most postoperative patients were still experiencing discomfort at the shoulder or were instructed by their surgeon to maintain shoulder immobilization.

Table 2 Quality of supraclavicular brachial plexus nerve block

	Control group	Group 1-mg dex	Group 2-mg dex	Group 4-mg dex	*P*
Intraoperative opioid (μg: fentanyl equivalent)	209.0 ± 95.6	200.8 ± 96.1	242.1 ± 105.0	192.0 ± 119.6	.297
PACU pain score	1.70 ± 2.03	1.11 ± 1.86	1.57 ± 2.56	0.72 ± 1.87	.148
PACU opioid (mg: morphine equivalent)	4.35 ± 1.58	6.02 ± 3.06	7.93 ± 4.50	8.59 ± 4.85	.077
PACU length of stay (min)	78.8 ± 38.0	72.3 ± 32.3	70.0 ± 32.7	74.8 ± 33.9	.904
Duration of analgesia (h)	12.1 (9.8-20.9)	22.3 (19.0-24.9)	23.3 (19.5-26.8)	21.2 (16.8-23.9)	.0105
Duration of motor block (h)	12.1 (8.9-19.4)	21.0 (16.8-22.7)	20.9 (16.1-23.7)	19.4 (14.9-23.2)	.0247
Patient satisfaction (Y/N)	19/1	17/0	18/1	19/1	.825

Abbreviations: *Y*, yes; *N*, no.

In vitro data have shown that dexamethasone increases neurotoxicity associated with ropivacaine [9]. However, an in vivo study in rat showed no long-term effect on nerve transmission or structure with local corticosteroid [11]. Furthermore, none of these previous human studies has reported any clinically relevant complications, although none of these studies has sufficient sample size to be conclusive. Our study patients had 1 episode of clinically significant paresthesia, which resolved in postoperative day 3. There is no additional complication identified throughout the study.

Our study has its limitations. First, all information was collected via telephone call during the patients' recovery period at home, which could confound veracity because recall may be inaccurate. Second, we did not control the intraoperative intravenous dexamethasone use for nausea vomiting prophylaxis, which could potentially affect the analgesia duration. This point was demonstrated after the publications by Desmet et al [12] and Fredrickson et al [13], which concluded that systemic-administrated dexamethasone was comparable in prolonging analgesia duration compared with perineural injection. We conducted a chart review on all our study patients; there were 8 patients who received intravenous dexamethasone (2/2/3/1 in each treatment group, respectively). We believe that the number of patients (8/76) is relative small and is unlikely to affect our conclusion (Table 1; $P = .731$). However, future investigation is needed. Third, we lost 12 patients during follow-up period as expected from our patient population. However, this could potentially introduce sampling bias.

In summary, dexamethasone prolongs analgesia duration with supraclavicular brachial plexus nerve block. Low-dose dexamethasone (1-2 mg) prolongs analgesia and motor block duration to a similar extent as 4-mg dexamethasone in addition to 0.25% bupivacaine for brachial plexus nerve block.

Acknowledgment

The authors would like to thank Mary Hammond for her assistance in initiating the study.

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British Journal of Anaesthesia **110** (3): 463–71 (2013)
Advance Access publication 27 November 2012 · doi:10.1093/bja/aes396

BJA

QUALITY AND PATIENT SAFETY

Challenging authority during a life-threatening crisis: the effect of operating theatre hierarchy

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Editor's key points

- This study investigated how hierarchy in the operating theatre (OT) team influences an anaesthesia trainee's ability to challenge an unethical decision by a consultant anaesthetist.
- No effect of OT team behaviour on the quality of trainees' challenges towards their consultant anaesthetist in a simulated crisis scenario was found.
- The quality of challenges did improve with increasing level of training.

Background. Effective operating theatre (OT) communication is important for team function and patient safety. Status asymmetry between team members may contribute to communication breakdown and threaten patient safety. We investigated how hierarchy in the OT team influences an anaesthesia trainee's ability to challenge an unethical decision by a consultant anaesthetist in a simulated crisis scenario.

Methods. We prospectively randomized 49 postgraduate year (PGY) 2–5 anaesthesia trainees at two academic hospitals to participate in a videotaped simulated crisis scenario with a simulated OT team practicing either a hierarchical team structure (Group H) or a non-hierarchical team structure (Group NH). The scenario allowed trainees several opportunities to challenge their consultant anaesthetist when administering blood to a Jehovah's Witness. Three independent, blinded raters scored the performances using a modified advocacy–inquiry score (AIS). The primary outcome was the comparison of the best-response AIS between Groups H *vs* NH. Secondary outcomes included the comparison of best AIS by PGY and the percentage in each group that checked and administered blood.

Results. The AIS did not differ between the groups ($P=0.832$) but significantly improved from PGY2 to PGY5 ($P=0.026$). The rates of checking blood (92% *vs* 76%, $P=0.082$) and administering blood (62% *vs* 57%, $P=0.721$) were high in both groups but not significantly different between the groups.

Conclusions. This study did not show a significant effect of OT team hierarchical structure on trainee's ability to challenge authority; however, the results are concerning. The challenges were suboptimal in quality and there was an alarming high rate of blood checking and administration in both groups. This may reflect lack of training in appropriately and effectively challenging authority within the formal curriculum with implications for patient safety.

Keywords: assertiveness; hierarchy; patient safety

Accepted for publication: 23 August 2012

Operating theatre (OT) team communication is crucial for efficient functioning, and its breakdown may endanger patient safety. Data collected in 2010 by the Joint Commission on Accreditation of Healthcare Organizations in the USA suggest that poor communication contributed to nearly 82% of sentinel events reported during the studied year. (http://www.jointcommission.org/sentinel_event_statistics_quarterly/, accessed July 13, 2011.) An analysis of 444 surgical malpractice claims revealed 60 cases in which patients were harmed by communication failures.[1] Another study looking at communication between anaesthesia, surgery, and nursing members of OT teams found that 30% of all

observed relevant communication events could be categorized as communication failures.[2] Furthermore, these failures led to threats to patient safety in one-third of cases.

Studies looking at the contribution of communication breakdown to real or potential patient harm have found multiple factors to be important. These include timing and location of information exchange, the content of the exchange, and the participants in the exchange.[1–3] The presence of status asymmetry, or hierarchy gradients, between team members is a definite contributor to communication breakdown, as it may lead to a hesitancy to communicate 'up the chain' or an inability to challenge an incorrect decision of a perceived superior.[1 3–5] This has been shown to be a significant contributor to patient morbidity and mortality. It is clearly demonstrated in the highly publicized case of Elaine Bromiley, a previously healthy woman, who died from a hypoxic brain injury after repeatedly failed intubation attempts by two consultant anaesthetists during elective surgery.[6] The two OT nurses subsequently stated that they knew what needed to be done to save this woman's life; however, they failed to assert themselves adequately. They chose indirect and passive statements, which may have been a result of the hierarchy present within the OT team, and were ineffective in a crisis situation.

A recent editorial introducing the concept of 'sociological fidelity' stated: 'the simulation literature continues to overlook the importance of sociological factors such as hierarchy, power relations, inter-professional conflict and professional identity, which are now well-known to affect inter-professional communication, collaboration and teamwork'.[7]

The primary aim of this study was to investigate how OT team behaviour that reinforces strict hierarchy influences an anaesthesia trainee's ability to challenge a clearly unethical decision by a consultant anaesthetist in a simulated crisis scenario. We also aimed to investigate the extent to which the trainee's level of training and personality profile modified their behaviour.

Methods

Study setting and participants

This multi-centre study was performed at two university departments of anaesthesia (University of Ottawa, Ottawa and Queen's University, Kingston) in Ontario, Canada. After approval from both institutions' research ethics boards, 60 anaesthesia trainees in postgraduate years (PGY) 2–5 of a 5 yr training programme were recruited on a volunteer basis to participate in a simulated crisis scenario. All of the trainees had previous experience participating in simulation. Written informed consent was obtained from each trainee before participation.

Each trainee was asked to complete a pre-test questionnaire to collect patient characteristic data and a personality questionnaire [NEO-Five Factor Inventory (FFI), SIGMA Assessment Systems, Port Huron, MI, USA]. The NEO-FFI is a validated short-form questionnaire that assesses the five-factor model of personality (openness, conscientiousness, extroversion, agreeableness, and neuroticism), an established model for describing personality traits.[8 9]

Hierarchy and sociological fidelity

In an attempt to achieve 'sociological fidelity' and maintain a hierarchy gradient in our simulation scenario, we used confederates (actors) to simulate professional conflict and interpersonal power relations. Trainees were randomized (stratified by PGY) using a sealed envelope technique to either (i) a simulated OT team with scripted behaviour intended to recreate a hierarchical team climate (Group H) or (ii) with scripted behaviour intended to recreate a non-hierarchical structure (Group NH). Table 1 and Appendix describes OT team behaviour in each group. The OT team consisted of actors trained to play scripted parts of two nurses, a consultant surgeon, and a consultant anaesthetist. We deliberately used deception in an attempt to illicit genuine responses from the trainees. Although the 'consultant anaesthetist' was an actor, the trainees were told that they were in fact interacting with a consultant newly recruited to the university, working at a hospital that the trainee would soon rotate through. This was done to maintain the 'natural' hierarchy structure between a trainee and a consultant. For the same reason, the trainees were also told that both they and the consultant anaesthetist were subjects in the study that was looking at anaesthesia teamwork in the OT setting. This deception was made explicit in the research ethics applications.

Each member of the team had a predetermined script for each team behaviour (hierarchical *vs* non-hierarchical), and the consultant anaesthetist was also given a standardized script of responses to a range of questions and challenges by the trainees (Table 2). 'Sociological fidelity' is a relatively new concept in simulation, and there is no literature describing the simulated reproduction of an OT climate. The behaviour of the intraoperative teams was therefore developed and

Table 1 Simulated OT team behaviour. Confederates in the simulated crisis scenarios attempted to recreate either a 'hierarchical' or 'non-hierarchical' team climate depending on randomization of the subjects

Hierarchical	Non-hierarchical
No introductions are made	Introductions to all members of the team are performed
Minimal eye contact, absence of social conversation	Good eye contact, friendly demeanour
Short, dismissive responses to resident questions	Responds completely to resident questions
Assertiveness and suggestions from resident not accepted	Assertiveness and suggestions from resident accepted and sought
Doctors are referred to as 'doctor', nurses as 'nurse'	All members of OT team use first names
Nurses do not speak up voluntarily	

Table 2 Modified score system for advocacy-inquiry. This table describes the AIS,[13] modified by adding an additional score of 6 if the resident attempts to take over the management of the case and the scripted responses by the staff anaesthesiologist to these various challenges by the resident

Type of language used to challenge	Score	Example	Consultant anaesthesiologist's response
Say nothing	1		Continue with anaesthetic management or transfusion depending on the phase of the scenario
Say something oblique, obtuse	2	'We're ordering blood for him?'	Say nothing, or something oblique, and continue with anaesthetic management or transfusion depending on the phase of the scenario
Inquire about the patient not wanting blood	3	'Didn't the patient say he didn't want blood?'	'This patient is ischaemia because he's anaemic. He's going to die if he doesn't get blood!'
Advocate for the patient's wishes not to have blood		'This patient has stated that he doesn't want a blood transfusion.'	
Advocate OR inquire repeatedly, with initiation of discussion	4	As above but repeatedly	'Sure he said that he didn't want blood, but none of us knew that we would be in this scenario, and I'm not prepared to let this man die!'
Use crisp advocacy-inquiry	5	'Dr Smith, this patient is a Jehovah's Witness. I'm concerned that by giving him blood we will compromise his right to refuse blood. I'm curious, have you thought about this?'	'I know he said he didn't want blood, but I never thought we'd be here, and I didn't know how I'd feel about it. It's against my beliefs to let him die. I can't do it. He'll thank me afterwards'
Attempts to take over case, calls in second anaesthetist or appeals to surgeon	6	'Attempts to dismiss staff from position, calls in 2nd anaesthetist, appeals to surgeon or rest of room for assistance, physically blocks blood administration'	'Fine, I don't want this guy's life on my hands! This is your case now'

tested by the investigator team during several pilot scenarios. The scenario and team interactions intended to create hierarchical or non-hierarchical climates and were piloted and refined in an iterative manner using general practice anaesthesia trainees as subjects. These pilot data were not included in the analysis of the study. Both medical and non-medical OT members scrutinized the performances of the actors during those pilots.

In the 'non-hierarchical' group, we included collaborative behaviours. For instance, the consultant anaesthetist introduces the arriving trainee to the whole intraoperative team. This is aligned with the widely adopted Surgical Safety Checklist which has been shown to improve patient safety.[10] By comparison, in the 'hierarchical' group, the trainee was not introduced to any other team member on arrival to the OT and the team members addressed each other by their profession rather than by name.

The scenario

The scenario began with the principal investigator introducing the trainee to the consultant anaesthetist and pre-briefing them together in a conference room regarding the purpose of the study and their roles in the simulation. They were then given 3 min alone together to familiarize themselves with a written preoperative assessment completed on the patient by one of their colleagues. One purpose of this initial meeting was to establish the behaviour of the confederate consultant anaesthetist (hierarchical *vs* non-hierarchical) before the start of the simulation scenario. The consultant anaesthetist was either amiable and talkative in the non-hierarchical group or silently checking a smartphone and indifferent in response to attempted conversation by the trainee in the hierarchical group. The preoperative assessment described a planned elective open bowel cancer resection in a 60-yr-old male with anaemia and risk factors for coronary artery disease. The patient was a practicing Jehovah's Witness and had strictly refused all blood products. The consultant anaesthetist was then asked to join the simulation scenario in the OT while the trainee was asked to wait in the conference room. The trainee was led to believe that the consultant anaesthetist was to start the case, and that the trainee would be called to assist if necessary. After 4 min, the trainee was called by the OT nurse to come help with the case at the request of the consultant anaesthetist. Upon entry into the room, the trainee was given a scripted handover regarding an intraoperative vascular injury with subsequent massive bleeding and was allowed to participate in the management of the case.

There were three distinct points at which the behaviour of the consultant anaesthetist invited a challenge from the trainee:

- Ten minutes into the scenario, the patient began to show electrocardiographic evidence of ischaemia, and a point-of-care test of haemoglobin showed severe anaemia (haemoglobin 5 g dl^{-1}). This prompted the consultant to order blood from the blood bank.
- When the blood arrived, the consultant asked the trainee to check the blood.
- Finally, after the blood had been checked, the consultant anaesthetist requested that the trainee administer the blood.

For each opportunity to challenge the consultant anaesthetist, there were scripted responses depending on the quality of the challenge (Table 2). The scenario was developed by the authors, and is similar in context to scenarios in a previous study on the 'two-challenge rule', in that it allows the subjects several opportunities to challenge a wrong decision.[11] However, as opposed to those scenarios, the scenario in our study was created to be independent of content knowledge and to focus on the trainees' willingness to challenge authority.

Most Jehovah's Witnesses firmly refuse blood product administration because of religious reasons,[12] and this is often documented before surgery (as in this scenario). While moral and ethical arguments about a physician administering blood to these patients continue, legal precedents in Canada,[13] the USA,[14] and the UK[15] have found physicians who followed this course of action to be guilty of battery. Medical cases involving blood transfusion and a Jehovah's Witness' right to autonomously refuse blood are prototypical ethical dilemmas and are taught extensively during medical school and anaesthesia training from both ethical and legal standpoints. The authors felt that this choice of scenario would be familiar to all trainees, and thus a trainee's behaviour would be relatively unaffected by a lack of previous clinical exposure to a similar case.

Data recording and analysis

Each trainee's simulation scenario was video recorded. When all of the data had been collected, the sessions were scored by three independent and blinded raters using a modified advocacy–inquiry score (AIS). The raters were asked to give one AIS score for each challenge opportunity. They were trained in using the scoring system, by individually scoring the pilot scenarios (not used in the analysis) and then discussing the scores as a group to assure consistency. The original AIS,[11] developed from the Advocacy-Inquiry method of debriefing,[16] included five scoring levels, and Pian-Smith and colleagues[11] reported evidence supporting the validity of this scale as the score increased after trainees were given specific instruction on challenging authority. In the current study, we added a sixth level in the case of a trainee attempting to take over the case (e.g. calling in a second anaesthetist, appealing to the surgeon for intervention, or physically blocking the consultant from hanging blood) to allow the measurement of a wider range of behaviours. Table 2 displays the modified AIS. Scores were averaged between raters as the average-measures intraclass correlation co-efficient was found to be high.

The primary outcome in this study was a comparison of the best modified AIS responses of the three challenge opportunities between the hierarchical *vs* non-hierarchical groups. We used the best response of the three challenge opportunities, regardless of the quality of the other two challenges, as we thought that the strongest challenge would be the most clinically relevant. Secondary outcomes included (i) a comparison of best-responses for the modified AIS by PGY (similarly to the primary outcome, we used the best response of the three challenge opportunities, regardless of the quality of the other two challenges), (ii) the percentage of trainees in each group that checked blood (regardless of whether they challenged), (iii) the percentage of trainees in each group that actually administered blood (regardless of whether they challenged), and (iv) a correlation of median best-responses for the modified AIS with gender and with each of the domains of the NEO-FFI personality questionnaire. Group allocation (hierarchical *vs* non-hierarchical) was assessed for an observable difference by a fourth independent video rater. This rater was not blinded to the purpose of the study but blinded to group allocation to ensure that it was possible to discriminate between the control and intervention groups.

Statistical analysis

Intraclass correlation coefficients were calculated for the video ratings to determine inter-rater reliability. The primary outcome was analysed using the Mann–Whitney *U*-test. An additional analysis of covariance was used to explore the potential effect of gender on the primary outcome with best modified AIS as the depended variable, group allocation as a fixed variable, and gender as a covariant. Secondary outcomes were analysed using a Kruskal–Wallis test and Pearson's χ^2 where appropriate. The data were analysed using SPSS 16.0 statistical software (Chicago, IL, USA).

Sample size calculation

In the fields of psychology and education research, targeting a large effect size is generally considered appropriate for the purposes of sample size calculation. Our sample size calculation was based only on our primary outcome variable, so secondary outcomes should be considered as hypothesis generating. Assuming an α of 0.05, a power of 80%, and a Cohen's *d* effect size of 0.9, and an asymptotic relative efficiency of the *U*-test relative to the *t*-test of 0.955, we determined that we needed 22 trainees in each group.[17] (http://www.stat.uiowa.edu/~rlenth/Power, accessed November 10, 2010.) To allow for technical failures and considering that participation in the study was a valuable learning experience that should be made equally available to all anaesthesia trainees at the institutions taking part, we invited all 60 PGY2–5 trainees to participate in this study.

Qualitative analysis

All debriefs were recorded and transcribed for later qualitative analysis. All participating trainees were interviewed after the debriefing to explore issues surrounding hierarchy, challenging authority, and how they perceived the scenario. These interviews were also recorded and transcribed for later qualitative analysis. This analysis is outside the scope of this current article and will be described elsewhere.

Results

Video data were complete for 40 (98%) trainees from the University of Ottawa and nine (47%) trainees from Queen's University, for a total of 49 (82%) eligible anaesthesia trainee participants. Nine trainees were unavailable to participate because of prior obligations, and two trainees were excluded from the primary outcome analysis because of poor audiovisual quality of the video recordings. Table 3 shows patient characteristics of the cohorts. Despite the drop outs after randomization, there remained similar numbers of each PGY in each group, but there were significantly more females in the hierarchical group. Table 4 shows the median scores for the personality domains in each group.

Inter-rater reliability among video raters was found to be high (ICC=0.71). The median best-responses for the modified AIS did not differ between the hierarchical *vs* non-hierarchical groups 4.00 (range 3.67–4.50) *vs* 4.00 (2.92–4.88) (P=0.83) (Fig. 1). When accounting for gender as a covariant, there remained no significant difference between the groups (P=0.76). The best-responses for the modified AIS significantly improved with the number of years in residency (P=0.03) (Fig. 2).

The rates of checking blood in the hierarchical and non-hierarchical groups (92% *vs* 76%, P=0.08) and administering blood (62% *vs* 57%, P=0.72) were not significantly different. There was no significant correlation found between gender (P=0.85) or personality domains and the median best-responses for the modified AIS (gender 0.85; neuroticism P=0.92; extroversion P=0.69; openness P=0.82; agreeableness P=0.31; conscientiousness P=0.40).

Regarding the assessment of hierarchical *vs* non-hierarchical group differences, the fourth independent rater correctly identified the group allocation in 100% of the videos.

Table 3 Patient characteristics

	Hierarchical group	Non-hierarchical group	Overall
Total number	26	23	49
Sex			
Male	9 (34.6%)	18 (78.2%)	27 (55.1%)
PGY			
2	7	5	12 (24.5%)
3	6	6	12 (24.5%)
4	7	7	14 (28.6%)
5	6	5	11 (22.4%)

Discussion

Our results showed no effect of OT team behaviour on the quality of trainees' challenges towards their consultant anaesthetist in a simulated crisis scenario. Personality type also did not correlate with the quality of the challenge. However, the quality of challenges did improve with increasing level of training (PGY). Final-year trainees' challenges tended to be at a relatively high level, such as the use of an advocacy-inquiry technique, attempting to take over the case, or at least repeated use of advocacy or inquiry with initiation of discussion (Fig. 2). Contrastingly, year 2 trainees' median best challenge was at the level of isolated inquiry or advocacy without initiation of a discussion. Overall, the majority of challenges at each stage of the scenario were of an oblique and indecisive nature (Fig. 1). The existing literature indicates that this type of challenge is likely to be ineffective.[1 3–6]

One of the most surprising results, and in our opinion also one of the most important, was that the majority of trainees in both groups both checked and gave blood to a Jehovah's Witness patient in this simulated crisis scenario, even after they had read a preoperative consult that stated the patient's refusal of this intervention.

There may be several explanations for the lack of difference between the groups. First, it may be that with our intervention, we failed to create a 'sociologically faithful' reproduction of different levels of hierarchy between the groups. Although we are confident that our model is suitable for testing the ability to challenge authority, and a rater was able to pick out the H and NH groups 100% of the time we cannot be sure how these differences were perceived by the trainees themselves. It could be argued that the behaviours in the 'hierarchical' group could be described as poor communication, unprofessionalism, or simply rudeness and further qualitative analysis is currently underway to identify this. Therefore, we accept that any conclusions relating to our primary outcome measure can only considered hypothesis generating rather than conclusive. Future research is necessary to identify

Table 4 Percentage of each group scoring in the low, average, or high range of the domains of the five-factor model of personality

Personality domain	Non-hierarchical group (n=23)			Hierarchical group (n=26)		
	Low (%)	Average (%)	High (%)	Low (%)	Average (%)	High (%)
Openness	8.7	43.5	47.8	23.1	38.5	38.4
Conscientiousness	26.1	43.5	30.4	15.4	42.3	42.3
Extroversion	8.7	43.5	47.8	19.3	26.9	53.8
Agreeableness	26.1	21.7	52.2	26.9	46.2	26.9
Neuroticism	47.8	43.5	8.7	30.8	42.3	26.9

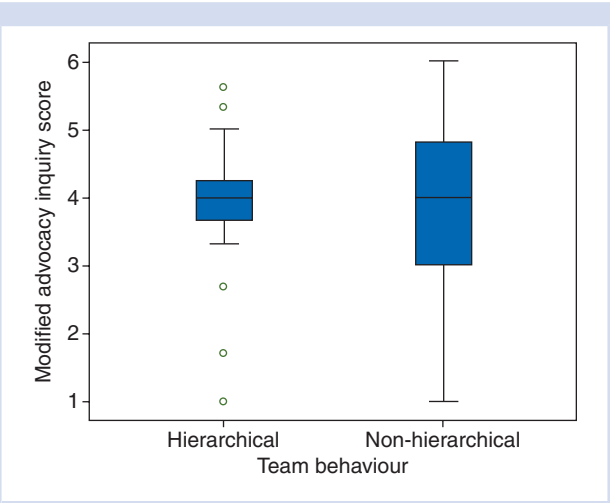

Fig 1 Challenges to authority with hierarchical *vs* non-hierarchical team behaviour. Horizontal black lines represent the median, the height of the boxes the inter-quartile range (IQR), the whiskers the range and the circle an outlier (outside 1.5 IQR). See Table 2 for details of the AIS.

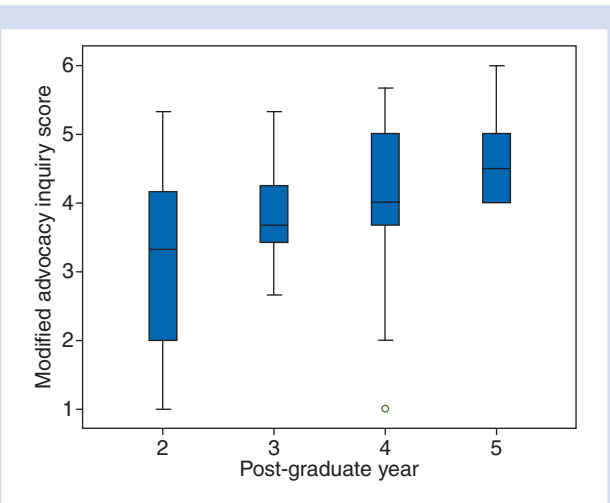

Fig 2 Challenges to authority by PGY. Horizontal black lines represent the median, the height of the boxes the inter-quartile range (IQR), the whiskers the range and the circle an outlier (outside 1.5 IQR). See Table 2 for details of the AIS.

how other professions such as nursing staff and anaesthesia assistants perform in this simulation model.

It is possible that there may be no true influence of hierarchy on the quality of challenges to authority. However, this is counterintuitive and contrary to the substantial literature supporting the negative effects of hierarchy on communication.[1 3–5] Alternatively, the absence of a statistical difference in challenge quality may have been due to a more pervasive influence of hierarchy in these trainees' daily practice. If trainees are frequently exposed to significant hierarchical behaviour during their training, this exposure may have long-lasting effects on their willingness and ability to challenge authority, regardless of their group designation in one simulated scenario. The ongoing qualitative analysis will also aim to clarify this issue.

The measured domains of the five-factor model of personality (NEO-FFI) were not related to the quality of challenges made by the trainees in this study. Several studies have looked at whether personality characteristics predict performance in anaesthesia residency and practice. They have found characteristics such as conscientiousness, dominance, responsibility, achievement via conformance, and alpha personality to predict better performance, whereas introversion and high flexibility predicted poor performance.[18–20] The lack of ability of the NEO-FFI scores to predict the quality of challenges in our sample could either be because personality type is less important than other factors, such as clinical experience, or because there was relatively little variation in personality type in our sample of anaesthesia trainees.

The improvement in performance with PGY may either reflect decreasing 'status asymmetry' between the more senior trainees (with more confidence in their clinical abilities) and the attending anaesthetist, or increased competence at challenging authority. If the latter, then this learning seems to demonstrate the existence of an informal curriculum,[21] as there is no formal teaching in challenging authority or conflict management in anaesthesia training at either institution. Our initial qualitative analysis suggests that most trainees believed the intentional deception in our study, and we suggest that this, and the fact that challenges improved with decreasing status asymmetry, supports the validity of our model for testing the ability to challenge authority for subjects naïve to the scenario.

A significant finding of this study was the low level of challenge quality across PGYs. This is especially concerning in the context of such an obvious threat to patient autonomy. We found the high rates of blood checking and administration to a Jehovah's Witness as a direct result of the superior consultant's instructions surprising. This is especially true in the context of such a clear-cut scenario that is taught extensively during medical school and residency training. We propose that the skills to advocate for patients should be included early in the formal curriculum to enable better use of the collective competence of all members of the perioperative team in order to improve patient safety. Similar to the established practice in the aviation industry, trainees should be given the tools to effectively and appropriately challenge their consultants. In aviation, with a well-established normative culture of safety, the concept of the 'two-challenge rule' has been 'institutionalized'.[22] If a pilot puts the aircraft's safety in danger, a subordinate team member must challenge the action twice if necessary. If no reply or if nonsensical replies are provided, the subordinate is empowered to take over control of the plane. The acceptance of challenging authority in aviation is part of crew resource management, a team philosophy that has been generally shown to produce positive reactions, enhance learning, and promote desired behavioural changes.[23] Certainly in medicine, it may be

that institution-wide education is required to foster awareness of the presence and potential harm of hierarchy in the medical team and a deliberate cultural change in the healthcare setting may be required.

Despite a multitude of Crisis Resource Management courses currently found across North America and the UK for trainees and practicing physicians, we found only one paper in the literature that described experiences in improving trainees' ability to challenge authority.[11] This study developed the AIS looking at anaesthesia trainees' ability to challenge a superior in two simulated obstetric scenarios. Despite using similar metrics, it is difficult to compare our modified AIS scores with that previous study as they analysed the mean scores for all challenges, not for the best challenge made, which we felt was more clinically meaningful. Also, our study concentrated on behaviour that was independent of content knowledge and only tested challenging authority.

This study has limitations that may affect interpretation. There is only one previous study using the AIS and this was not primarily a validation study. However, the demonstration of improved AIS scores after training in challenging authority supports the validity of this tool.[11] Although we modified this scale by adding a sixth upper level for trainees taking over the case, there are clear theoretical reasons from the literature[11] why this should be considered the highest level of performance and so should be captured by the rating scale. Our own data showing the improvement with increasing residency experience support the construct validity of this modified scale. Despite the randomization process, the two groups had uneven gender representation, with Group H having three times as many women than Group NH. While gender differences may contribute to a difference in communication style, our results showed no correlation between gender and the quality of challenge. Finally, this scenario, as with all simulation scenarios, may suffer from a possible Hawthorne effect, a phenomenon which describes a change in participant performance due solely to their conscious participation in a study.[24] Methods used in this study to reduce this possible bias included using a high-fidelity simulator and using intentional deception when introducing the trainees to the consultant anaesthetist.

We conclude that although our study did not demonstrate an impact of a scripted hierarchical behaviour on trainees' ability to challenge a wrong decision by their consultant, it did demonstrate many failures to effectively challenge a wrong decision by a superior. As a result, the majority of trainees were willing to comply with a clearly wrong decision and check or administer blood to a Jehovah's Witness. This behaviour may reflect a gap in the formal curriculum, which may affect patient safety. Future research may investigate whether our findings are consistent with other institutions and specialities which may have different medical cultures.

Acknowledgements

We would like to acknowledge the contributions of Chilombo Bould, Asad Mirghasemi, Andrew Karam, Maryam Mirghasemi, and Alvi Rahman, for being confederates, Chilombo Bould for reviewing the manuscript, and Julie Ghatalia for technical support.

Declaration of interest

None declared.

Funding

This study was supported by a University of Ottawa Educational Initiatives in Residency Education grant, Ottawa, Ontario.

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Appendix: Scenario plan and scripting

Phase	Min	Non-hierarchical team	Hierarchical team
1. Start: consultant anaesthetist and trainee are introduced to each other and 'purpose' of the study is discussed with both	1	Consultant anaesthetist friendly and talkative. Engaging to trainee	Consultant anaesthetist makes minimal effort to greet trainee. Shows little interest in communication with trainee
2. Briefing: trainee and consultant anaesthetist receive consult form to read in the waiting room	3	Consult has been done by another trainee on call overnight. Details: • 'Ischaemic heart disease, long history of stable angina but recently notices a decrease in exercise tolerance' • 'Jehovah's Witness—no transfusions'	
3. OT introductions: trainee is sent to OT to assist consultant anaesthetist; enters OT; introductions to OT team	1	• 'Thank you for coming to help. What's your name again?' • To team: 'Everyone, this is "Trainee X" who's come to help us out' • Team members introduce themselves by first name	• 'Trainee, what's your name? I'm Dr Smith' • No introductions to OT from the team
Cue for next stage: circulating nurse changes BP cuff and states: 'Do you want me to cycle the BP cuff?'			
4. Information transfer	2	• Consultant anaesthetist to trainee: 'This is a standard colon resection, but there has been a vascular injury, and he has lost a lot of blood. I've given a lot of fluid for resuscitation but he is still hypotensive. Could you please draw up more phenylephrine? I'm currently running a Hemocue to check the haemoglobin' • Surgeon to scrub nurse: 'Cathy, you gave me a blue clip, but I need a red clip please; the blue clips are too small for this kind of vessel. Thank you'	• Consultant anaesthetist to trainee: 'We've got a lot of blood from a vascular injury. Draw up more phenylephrine' • Surgeon to nurse: 'Nurse get me a red clip; you should know what size of clip I need. It's not rocket science'
Cue for next stage		• Consultant anaesthetist to trainee: '"Trainee X" the Hemocue should be done now; could you please check where we're at?'	• 'Get the Hemocue result'
5. Hemocue result: 5 g dl^{-1}		ECG starts showing ischaemia (noted verbally by consultant anaesthetist)	
6. Call for blood (first opportunity to challenge authority—see consultant anaesthesiologist's scripted responses to challenges, Table 2)	3	• Consultant anaesthetist to circulating nurse: 'Linda our Hemocue came back as 5, and we're starting to see some myocardial ischaemia. I am getting worried about this patient. Would you please call down to the blood bank for 4 units of Type-O positive blood, as we do not have a type and cross?' • Scrub nurse to surgeon: 'Bill is there anything else that I can get you?'	• Consultant anaesthetist to nurse: 'Nurse, call the lab and get 4 units of O-positive now' • Scrub nurse to surgeon: 'Dr Blade is there anything else that I can get you?' • Surgeon to nurse: 'Can't you see I'm working to control this bleeding? The more you talk the less I get done, so being quiet is essential' • Consultant anaesthetist to surgeon:

Continued

Appendix *Continued*

Phase	Min	Non-hierarchical team	Hierarchical team
		• Surgeon to nurse: 'Linda, I will need you to continue holding this retractor for me. You are doing a great job at assisting' • Consultant anaesthetist to surgeon: 'Bill, we're doing everything we can here to maintain a blood pressure, and we are going to administer some blood to the patient. How are you doing with surgical haemostasis?' • Surgeon to consultant anaesthetist: 'Mary, I appreciate everything you are doing behind the drape. I am working hard to attain haemostasis'	'Dr Blade we are about to give blood. Have you almost controlled your bleeding?' • Surgeon to consultant anaesthetist: 'I will get control of the bleeding quicker if I don't need to think about your side of the drapes. Just keep the patient from dying'
Cue for next stage: circulating nurse says to consultant anaesthetist: 'I used to work in the cardiac unit and that looks like ischaemia on the ECG'			
7. Blood checking and administration (second and third opportunities to challenge authority—see consultant anaesthetist's scripted responses to challenges, Table 2)	2	• Consultant anaesthetist to circulating nurse and trainee: '"Trainee X" and Cathy, would you please quickly check the blood to ensure it is O-positive? "Trainee X" please give this blood immediately after you check it, as this patient is bleeding out, and his heart is already becoming ischaemic'	• Consultant anaesthetist to circulating nurse and trainee: 'Nurse, you and this doctor check and give the blood stat. The patient and his heart are dying'
8. End scenario • If blood given then stop scenario when blood connected and i.v. opened • If blood not given because trainee attempts to take over case, calls in second anaesthetist OT appeals to surgeon to take over the case then stop scenario immediately after consultant anaesthetist concedes control of patient management • If trainee leaves the room then stop scenario			

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