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Editorial

Secondary cervical spine injury during airway management: beyond a one-size-fits-all approach

Secondary spinal cord injury following airway management is a rare but potentially devastating complication. Not surprisingly, clinicians place a primacy on minimising cervical spine movement by maintaining manual in-line stabilisation – though this itself may complicate airway management.

Consider the case of a young unrestrained driver presenting to the emergency department after a high-speed motor vehicle collision. He is hypertensive and bradycardic, with a dilated and unresponsive left pupil. He is on a spinal board with a rigid cervical spine collar. Given the high-force mechanism and evidence of traumatic brain injury, the probability of a cervical spine fracture or spinal cord injury would be approximately 7% and 2%, respectively [1, 2].

Manual in-line stabilisation is maintained and the anterior portion of his cervical collar is removed. Direct laryngoscopy is difficult and multiple attempts at tracheal intubation are required. His trachea is intubated using videolaryngoscopy on the third attempt; however, there is evidence of tracheal aspiration of gastric contents. The intubating doctor, a junior trainee, is replaced by a senior trainee and finally the consultant emergency physician. Arterial oxygen saturation falls to 90% throughout these attempts, despite two-person bag-valve-mask ventilation using an oral airway. In addition, the patient's systolic blood pressure transiently drops below 80 mmHg after the second attempt. In this scenario, airway management predicated on manual in-line stabilisation, and without a consolidated management plan, results in multiple recurrent threats of secondary injury to his spinal cord.

This illustrative case demonstrates the challenges facing clinicians and highlights the important question: what is the optimal management of the airway in critically ill patients with potential cervical spine trauma to prevent secondary or iatrogenic injury? The goals surrounding airway management in this population are twofold: i) minimise mechanical movement of the cervical spine during tracheal intubation; and ii) avoid hypotension and hypoxaemia which themselves can lead to secondary spinal cord injury.

The first goal, minimising mechanical movement during laryngoscopy, is the question posed in a study by McCahon and colleagues, recently published in *Anaesthesia* [3]. Using a cadaveric model of a type-2 odontoid fracture, the authors examined the changes in the space available for the spinal cord comparing three laryngoscopes: the Airtraq® (Airtraq LLC, Fenton, MO, USA) videolaryngoscope, the Macintosh direct laryngoscope and the McCoy direct laryngoscope. Six unembalmed elderly female cadaveric specimens were used. Cervical spine motion at the C1-2 segment was assessed before and after a base-of-odontoid fracture was produced using an osteotome through the posterior pharyngeal wall. The primary endpoint of the study was the change in the space available for the spinal cord at the C1-2 segment during laryngoscopy and tracheal intubation. The space available for the cord was determined in real time by a radiologist using fluoroscopy. In order to simulate real-world conditions, manual in-line stabilisation was maintained and direct laryngoscopy was undertaken under a modified Cormack and Lehane grade-2b view with a bougie used as an adjunct. In addition to movement during laryngoscopy, the authors also measured the space available for the cord in maximum flexion and extension before and after the injury.

The authors concluded that there was no change in the space available for the spinal cord comparing all three laryngoscopes at any stage of tracheal intubation, either

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before or after injury. In addition to the space available for the cord, the authors examined changes in angulation and distraction of the C1-2 segment. The only significant finding was an increase in angulation between the stable and unstable state during tracheal intubation with the Macintosh laryngoscope. There was no significant change in angulation with either the Airtraq or McCoy laryngoscopes.

Overall, McCahon et al. presented a study with excellent standardisation of laryngoscopic attempts and meticulous assessment of their outcomes of interest. Minimising cervical movement by obtaining the minimal necessary view for laryngoscopy, and by using a bougie, reflects real-word practice. The choice of an odontoid model was well justified, as 25% of unstable cervical spine fractures occur at this level. Finally, the topic is of critical importance to practising anaesthetists. There are a few specific points regarding the study that deserve discussion. Despite the demonstrated odontoid fracture, there was no difference in the space available for the spinal cord during maximum flexion or extension. The authors correctly acknowledge that this lack of instability in their model would limit the ability to demonstrate any difference with laryngoscopy. The authors created a limited odontoid fracture without ligamentous injury, most likely limiting the degree of instability. Furthermore, because of the small sample size, the study was underpowered to detect any significant difference. The negative results of this study must be interpreted with caution because of the high risk of a type-2 error. The authors performed a retrospective power calculation to help interpret their non-significant results. However, power is an a-priori concept and should only be used when designing studies; performing post-hoc power calculation is problematic [4].

McCahon et al. measured the space available for the spinal cord as their primary endpoint. This was chosen because of the risk of mechanical compression, reducing the space available for the cord. However, neurological injury is usually multifactorial and more complicated than simply mechanical compression. Cervical spine trauma tends not to be isolated to simply a fracture site. Ligamentous injury [5], surrounding tissue oedema and haematoma formation all play a role in the trauma patient. Transection of the cord or contusion during airway manipulation may also be important. Even the use of a cervical spine collar may increase jugular venous pressure and decrease spinal cord perfusion pressure [6]. Superimposed on these mechanical and structural issues is generalised or local hypoperfusion or hypoxia, which may also play a prominent role in secondary spinal cord injury. Because of the nature of their injury, hypotension and respiratory failure are common in patients with traumatic spinal cord injuries [7, 8]. In traumatic brain injury, hypotension and hypoxaemia are consistent risk factors for mortality and worse neurologic outcomes [9, 10]. Thus, limiting repeated attempts at laryngoscopy is paramount, as this itself is independently associated with hypotension and hypoxaemia in the emergency setting [11–13].

Practical management

How do we clinicians apply the results of this study to our patients with possible or known cervical spine fracture? Secondary spinal cord trauma directly attributed to airway management is a rare event [14]. In one retrospective study from a regional referral spinal cord centre, only four out of 1031 (1.8%) patients sustained a neurological deterioration attributed to airway management [15]. Complicating this ascription, 2-5% of patients with spinal cord injuries will have a secondary neurological deterioration, even with the best of care. In his comprehensive review on the topic, Crosby states: "*A diagnosis of ascending myelopathy must be considered when a secondary injury has occurred; there is a natural temptation to attribute the deterioration to temporally related clinical interventions but, in fact, these interventions are rarely associated with neurologic sequelae*" [16].

Examining the American Society of Anesthesiologists' Closed Claims database, there were 37 claims for spinal cord injuries between 1970 and 2007. Only seven were due to traumatic spinal cord injuries before a surgical procedure. There were nine patients with documented cervical spine instability. In two of these, airway management was thought to be a probable contributor to the neurological deterioration. Laryngoscopy in both patients was reported to be difficult, and was performed without manual in-line stabilisation [17].

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If neurological deterioration due to airway management is a rare event, attempting to evaluate whether a particular technique is better or worse than another is exceedingly difficult. Not surprisingly, the most literature in this area involves animal or cadaveric studies, with their inherent limitations. The majority of live human studies either are performed in healthy normal volunteers presenting for elective surgery, or describe data from a database where specific airway management details may not be recorded. Clinical studies are often limited to small retrospective case series or case reports. Because of the rarity of neurological injury and the lack of high-quality human data, the ability to study the safety of a particular technique is limited [18, 19]. The inability to assess and weight the circumstances surrounding neurological deterioration retrospectively, in the setting of spinal cord injury for individual patients, has led to heated debates in the literature, particularly with respect to the role of airway management [20–22].

Improving outcomes

Perhaps, rather than focusing on specific techniques, the real gains in preventing secondary injury lie in improving the process of care: communication; prevention of multiple attempts at tracheal intubation; and prevention of hypoxaemia and hypotension. There is no question that less cervical spine motion is a reasonable goal during the resuscitation of a trauma patient with presumed spinal injury. A high index of suspicion, and the use of robust screening tools for possible cervical spine injury, are indicated [23]. Developing and communicating an airway management plan is paramount [24]. The best way to achieve this goal consistently is to develop a tracheal intubation checklist, which has been strongly advocated following the Fourth National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) [25]. Tracheal intubation checklists help to ensure that patients are properly assessed and optimised, airway equipment is available, and the management plan is communicated to the team. They may also reduce the risk of multiple attempts at tracheal intubation and associated major complications, including hypoxaemia and hypotension. In their multicentre interventional study, Jaber et al. studied the implementation of a ten-point tracheal intubation protocol. There was a decrease in both life-threatening (21% vs 34% $p = 0.03$) and total (9% vs 21%, $p = 0.01$) complications after the protocol was implemented, compared with before [26]. However, successful implementation of best practice is difficult, and requires system-wide change and agreement from all stakeholders [27].

The specific tracheal intubation strategy [24] is dependent on multiple factors, including: physical examination and physiology of the patient; experience of the practitioner; and situational context (time of day, availability of experienced assistance and equipment) [28]. Although many trauma patients are unable to comply fully with a complete airway examination [29], the examination findings and the knowledge that manual in-line stabilisation will hinder mask-ventilation and laryngoscopy are helpful in choosing which intubation device may be superior for that individual patient. Removing the anterior portion of the cervical collar is essential, as the collar limits adequate jaw thrust and decreases mouth opening. Despite the concerns of worsening laryngoscopic view, manual in-line stabilisation still remains a standard of care when performing direct laryngoscopy [30]. However, not a single device has been shown to be superior over another in this clinical situation, because of the variation in patient, clinician and contextual factors.

Research and enthusiasm regarding videolaryngoscopy has increased in the past decade, including several studies examining cervical spine motion. Turkstra et al. published some of the earliest studies in this area, using fluoroscopy and manual-in line stabilisation in normal healthy volunteers. They found that the GlideScope® (Verathon Inc, Bothell, WA, USA) videolaryngoscope was associated with a 50% decrease in motion at the C2-5 segments compared with direct laryngoscopy. However, there was no difference between devices at the C1-2 segment [31]. In a similar study by the same authors, the Airtraq was compared with direct laryngoscopy. The Airtraq was associated with less motion at the occiput-C1, C2-5 and C5-thoracic segments. Once again, there was no difference between the Airtraq and direct laryngoscope at C1-2 [32]. However, it is likely that there are differences between videolaryngoscopes. Bruck

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et al. compared the C-MAC® (Airway World, Karl Storz GmbH and Co, Tuttlingen, Germany) and GlideScope videolaryngoscopes under manual in-line stabilisation in patients with cervical spine pathology undergoing elective surgery [33]. Despite comparable glottic views with both devices, the GlideScope had a higher first-attempt success rate (93%) than the C-MAC (58%).

Compared with direct laryngoscopy, videolaryngoscopy consistently leads to an improved glottic view [34]. However, this is an inadequate clinical outcome as it does not necessarily translate to improved first-pass success in unselected patients. Furthermore, there are situations that lend themselves to videolaryngoscopy failure: altered neck anatomy; presence of a surgical scar; history of neck radiation; and airway mass [35]. Despite the many 'pro-con' debates and opinions suggesting the demise of direct laryngoscopy [36], our view is that they are excellent complementary devices; each has the potential of 'rescuing' one another. Rather than focus on which device is 'best', practitioners should gain and maintain skills using two different devices that are distinct from one another, as well as their chosen airway rescue technique.

Many of us work at teaching centres, and we all need to learn how to manage these high-stress, high-risk, situations. However, there may be times when the most experienced person needs to perform the first attempt at tracheal intubation, particularly when the risk to the patient if the first attempt fails may be life-threatening.

The study by McCahon et al. is an important addition to the literature. However, as clinicians taking care of patients, we must do better than simply focusing on a 'one-size-fits-all' approach of which specific device is 'best.' Perhaps it is time to turn from the best device to the best-experienced people working as a team [37]. By maintaining communication skills, situational awareness, technical excellence and flexibility, as well as establishing a planned tracheal intubation strategy tailored to the individual patient, we will improve patient safety and outcomes.

Competing interests

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Editorial

Too much blood pressure?

This editorial is about our (anaesthetists') preoccupation with pre-operative blood pressure. In it, I propose that abrupt unilateral cancelation or postponement of operations due to raised blood pressure readings is wrong, that the pre-operative management of blood pressure measurement is often care-

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