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Editorial

New perspectives on airway management in acutely burned patients

A previously healthy 37-year-old man sustains a flash burn to his face after lighting a bonfire using accelerants, late on a Saturday night. The local ambulance service is called and a first responder paramedic attends. The patient is conscious, with erythema and small areas of blistering localised to a mask-like distribution of his face. He has singed nasal hair and eyebrows and carbonaceous sputum, but no immediate skin loss. He is triaged according to the Major Trauma Decision Tool and deemed appropriate for immediate transfer to a local emergency department (ED). On arrival, rapid assessment reveals that his injuries are limited to facial burns only. The on-call anaesthetic registrar identifies that while the patient's lips are swollen, there is no evidence of burn or swelling inside his mouth or upper airway. The on-call anaesthetic consultant is phoned and states that while the patient has clinical signs indicative that tracheal intubation should be undertaken, advice should be sought from the regional burns centre. The on-call intensive care consultant at the regional burns centre advises that the patient be monitored in a steep head-up tilt for several hours, that intravenous fluid therapy be restricted to maintenance therapy only, and that he will call and talk to the patient by phone every hour until all are satisfied that the patient's voice is unchanged and that his airway is not at imminent risk of obstruction. He also explains that if the patient's trachea is intubated, the nearest available burns intensive care unit (BICU) bed is 300 miles away; however, if not then an appropriate bed is available at the regional burns centre, 30 miles away. After several hours of monitoring, speaking with the patient, and resisting pressure to expedite the patient's transfer due to breaching of the ED's 4-h wait policy, the patient is deemed safe to transfer without tracheal intubation. He arrives at the regional burns centre in the early hours of Sunday morning; his burns are assessed, dressed and analgesia given. He is discharged home later that day with advice on analgesia and further care; continued specialist care and dressings are provided on an outpatient basis.

The above scenario is based loosely on an actual case; while the scenario will be familiar to many who work in UK acute burns units, the actual airway management and transfer may be somewhat different. Part of this variation is due to the complex infrastructure that exists in the UK for the provision of burn care. Of the UK's 18 adult and eight paediatric burns facilities, not all are co-located with Major

Trauma Centres (MTCs), and not all are able to manage patients requiring invasive ventilation; this makes the pattern of patient referral/transfer complicated and dependent upon the patient's local healthcare infrastructure. Primary transfer to a specialist burns facility is not often an option. Burned patients will often receive initial management in a local ED, in their regional MTC, or in the pre-hospital setting. For those with severe facial burns, the need for immediate tracheal intubation is usually obvious and takes place as soon as appropriate expertise is available, wherever that is.

However, for patients with less severe burns, such as the one described above, airway management decisions are more complex. In the UK, these patients frequently present to their local ED, where the decision for tracheal intubation will be based on assessment of the likelihood of imminent airway obstruction, the need for transfer to specialist care, and the time taken for such a transfer to take place. Thus, until the infrastructure of UK burns care alters significantly, such that all burned patients are managed primarily in specialist centres, local EDs will continue to be faced with infrequent but extremely challenging decisions about burned patients, particularly regarding their airway management. As depicted in the case described above, the avoidance of tracheal intubation can result in a far shorter transfer to specialist care, and a lack of exposure to the risks of intubation. However, in reality, many such patients undergo tracheal intubation purely to facilitate safe transfer. This is supported by data from the UK National Burn Injury Database (NBID; see http://ibidb.org), which show that between 2003 and the end of 2012, 173 (17%) of 1029 patients acutely admitted to BICUs after tracheal intubation underwent extubation within '0 days of ventilation', with 505 (49%) undergoing extubation within '1 day of ventilation' (NBID, personal communication).

These data highlight that current assessment criteria have a low specificity for predicting airway obstruction following burn injury. While over-triage may be necessary to avoid the risk of catastrophic airway obstruction during transfer, it is vital to recognise that tracheal intubation introduces morbidity in its own right (Table 1). It also

Table 1 Risks/considerations relating to tracheal intubation, invasive ventilation and inter-hospital transfer (for those requiring invasive ventilation) for patients with burn injury.

Tracheal intubation
Facial burns may complicate pre-oxygenation and mask ventilation
Laryngoscopy may be hindered by excessive secretions, soot, and oedema leading to distortion of the glottis and supraglottis [1]
Pulmonary aspiration is more common in emergency tracheal intubation [2]
Patients with subglottic injury may be at a greater risk of developing tracheal stenosis following intubation [3, 4]
Co-existing burn shock increases the likelihood of worsening hypotension on induction
Desaturation will occur faster in the presence of acute pulmonary pathology and a raised metabolic rate
Rare complications include granuloma formation, laryngeal chondromalacia and tracheoesophageal fistula [1]
Invasive ventilation
Sedation frequently results in hypotension, potentially contributing to the phenomenon of 'fluid creep', with exacerbation of interstitial oedema [5]
Vasopressor use in the presence of interstitial oedema may further compromise perfusion to burn wounds, and can potentially exacerbate and extend the area of burn necrosis [6]
'Iatrogenic' airway oedema resulting from the intubation process may prolong the need for sedation and invasive ventilation, with the attendant risks that such management brings
Inter-hospital transfer
Transfer to a burns intensive care unit (BICU) becomes mandatory once the trachea is intubated
BICU beds may be unavailable in the nearest burns unit, necessitating transfer over greater distances
Long-distance transfers are associated with increased risk of hypothermia on arrival at the specialist centre [7], and hypothermia can delay initial surgery and produce increased mortality [8]
Even if tracheal extubation follows rapidly, a second transfer to a local centre may not be safe for a number of days, and will disrupt continuity of care

raises the possibility that some patients may receive prolonged ventilation due to complications arising as a result of intubation performed purely for the purposes of transfer.

In this editorial, we review the pathophysiology of airway burns and the existing assessment criteria for airway compromise. We propose that with increased use of technology and a more patient approach to airway assessment in mild to moderate facial burns/scalds, we might improve the specificity for assessing airway compromise and reduce the need for, and complications from, tracheal intubation.

Pathophysiology of airway burns

Both the onset and the severity of airway oedema are difficult to predict accurately, and we know surprisingly little of the natural history of airway pathology following thermal injury [9, 10]. Thermal injury to the oral cavity and throat can cause oedema; with severe injury, airway obstruction may result as a consequence of oedema of the supraglottic airway and, in particular, the false vocal cords [11]. In many cases, clinically significant obstruction only occurs following fluid resuscitation, with maximal oedema typically presenting 8-36 h after the initial insult, and lasting for up to four days [5, 11, 12].

Current practice for assessing the burned airway

It is common practice to maintain a high index of suspicion for the development of airway obstruction, and a low threshold for early tracheal intubation; this is reflected and advocated in much of the medical literature. Clinical signs such as a hoarse voice and carbonaceous sputum are frequently cited as predictors for the development of airway obstruction [13]; the 2001 American Burns Association practice guidelines provide the most recent guidance on airway management after thermal injury and suggest that while "*prophylactic intubation is not indicated for a diagnosis of inhalation injury alone*", intubation should be "*strongly considered*" if there is concern over "*progressive oedema occurring during transport to the burns unit*" [14].

The question then is how can we better predict progressive airway oedema that may lead to airway obstruction? Current teaching is that the above clinical signs, together with a history of impaired consciousness or confinement within a burning environment, predict airway oedema and potential obstruction [15]. However, the UK data suggest that either these recommendations are being ignored, with too liberal an approach to tracheal intubation, or the clinical signs lack specificity. Certainly there are additional, albeit limited, data to support our concern that some burned patients are undergoing intubation when a more conservative approach may suffice (NBID and [15, 16]). However, there is very little evidence on the management and subsequent outcomes of patients with airway compromise after severe burn injury. In addition, the relative rarity of severe burn injury means that clinicians in non-specialist centres have infrequent exposure.

Determining the need for tracheal intubation

Data from burns centres consistently show that only a minority of patients with burns require airway intervention. As early as 1976, Bartlett et al. [15] reported that of 740 patients admitted to a regional burns centre, only 36 required tracheal intubation within the first 24 h despite over 300 having burns to the face and neck and 250 having a history consistent with inhalation injury. More recently, Eastman et al. [16] retrospectively reviewed 11 143 patients admitted to a regional burns centre over a 23-year period from 1982 to 2005; 11% underwent tracheal intubation before arrival, either at the scene or in a local ED. Of these, the mean total body surface area burned was 35%, inhalation injury was suspected in 26%, and mortality was 30%. Tracheal extubation took place on the day of admission in 12%, on the first day in 21% and on the second day in 8%. Only one patient required re-intubation at a later date, for reasons unrelated to his initial thermal injury. This is similar to the UK data collected by NBID and, given the usual time of onset and remission of airway oedema and clinically significant lung injury, it is our opinion that a significant number of Eastman et al.'s patients could have been safely managed without tracheal intubation and with non-invasive respiratory support. (Though of note, patients who underwent tracheal intubation and subsequently died

were excluded from further analysis, and may represent a subset for whom early tracheal intubation was indeed indicated).

Decisions to intubate patients' tracheas often appear to us to be taken too early, without adequate time for assessment of progress. This is compounded by the frequent use of over-simplistic criteria rather than adopting detailed and expert airway assessment followed by discussion with the regional burns unit.

Clinical signs such as facial burns, hoarseness, drooling, carbonaceous sputum and singed nasal hairs raise the possibility of airway involvement, but they are unreliable and poor predictors of injury severity [1, 11, 17–19]. Reliance on these signs may also lead to patients with clinically significant airway involvement going undetected [18, 19]. In a prospective observational study including 100 patients with clinically suspected inhalation injury [18], fibreoptic evaluation showed that 21% had no evidence of upper airway pathology and 39% had no evidence of tracheobronchial pathology, while 38% with evidence of upper airway injury did not present with singed nasal hairs. Similarly, a retrospective study of 41 patients [19] found that while facial and body burns were predictive for laryngeal oedema, there was no correlation with carbonaceous sputum and soot in the oral or nasal cavity, stridor, hoarseness, drooling or dysphagia. It is vital to differentiate burns and swelling around the lips and face from those in the mucosa of the mouth/oropharynx and in the supraglottic/glottic regions, the more distal injuries being much rarer, and more likely to cause airway compromise.

Although a number of investigations are used routinely to assess the adequacy of gas exchange and oxygen delivery (e.g. arterial blood gas analysis with co-oximetry), diagnosis of upper airway obstruction is more challenging. Fibreoptic evaluation may currently be the most promising diagnostic strategy [1, 18], but abnormal flow volume curves have also been shown to correlate with the degree of supraglottic injury, and can predict the need for eventual intubation [20, 21]. Lateral-view neck radiographs are unlikely to show glottic or supraglottic swelling [1], and initial chest radiography is a poor predictor of inhalation injury [22]. Similarly, while raised carboxyhaemoglobin levels suggest possible thermal airway injury, normal levels do not exclude it [1].

Fibreoptic examination

Bronchoscopy has long been used to identify inhalation injury [11, 23–25], but is unnecessary if subglottic pathology is unlikely. It may require sedation and laryngeal anaesthesia, and is poorly suited to serial assessment in a busy ED. In the early resuscitation phase, serial laryngeal examination with a fibreoptic nasendoscope provides a simpler and less invasive method for rapidly identifying supraglottic oedema, thereby helping to determine which patients require intubation [1, 18, 19]. In patients with clinical signs suggestive of thermal airway injury, a normal endoscopic appearance is reassuring and can be repeated at intervals or if there is clinical deterioration. The presence of mucosal oedema, mucosal hyperaemia and pooling of secretions indicates thermal injury, and suggests the need for close observation with repeated assessment; more sinister signs include narrowing of the laryngeal inlet, mucosal erosion, ulceration and exudation [18].

At present, the evidence to support routine nasendoscopy in this patient group is limited. In a small prospective series, Muehlberger et al. [1] reported 11 patients admitted to a regional burns centre. All had suspected inhalation injury, six had upper airway signs consistent with established indications for tracheal intubation, and eight had at least four clinical signs suggesting upper airway compromise. Fibreoptic laryngoscopy was performed on each patient: seven had minimal supraglottic oedema and only mild pooling of secretions. The remainder had moderate to severe supraglottic or glottic oedema, resulting in anatomical distortion. After two further examinations at 2-h intervals, all patients were deemed to have an 'adequate, stable airway' and none of the 11 required intubation. Although based on only a handful of patients, this study demonstrates the utility of fibroptic nasendoscopy in both diagnosis of airway pathology, and repeated examination to determine progression or lack thereof.

Recently, Ikonomidis et al. [18] proposed an inhalation injury score, based on fibreoptic evaluation of the upper airway and tracheobronchial tree. Utilising the oesophageal

mucosal injury endoscopic criteria, a grade of 1-3 is assigned individually to both anatomical regions depending on the presence of oedema, hyperaemia, bullous mucosal detachment, ulceration and necrosis. In the future, such scoring systems may help guide clinicians and provide a more objective framework on which to base decisions; whatever the system, they will almost certainly incorporate some sort of fibreoptic airway assessment. However, in the meantime, there can be no substitute for patient and repeated airway assessment by an experienced anaesthetist while minimising iatrogenic oedema formation through upright positioning and the avoidance of over-zealous fluid therapy; for most isolated mild to moderate facial burns/scalds, maintenance fluid therapy alone is adequate. The use of nasendoscopy seems prudent given the likely improvement in diagnostic accuracy and subsequent care.

Conclusions

Existing data (NBID and [15, 16]) and our own experience suggests that a significant proportion of patients who present with mild to moderate facial burns, no respiratory distress and minimal co-existing acute pulmonary or systemic pathology could initially be safely managed in the primary receiving hospital with non-invasive supportive measures, without subsequent development of clinically significant airway obstruction. It is important to consider the morbidity and mortality associated with tracheal intubation in such patients, and of the risks posed by unnecessary transfer to distant sites that may result.

However, we fully acknowledge the difficulties in determining which patients will follow a benign course, and which will develop airway obstruction and require invasive airway support.

Given the lack of sensitivity and specificity of clinical signs for the development of airway obstruction, we advocate greater use of fibreoptic technologies in assessing burned patients' airways on admission and at pre-defined intervals or if there is evidence of clinical deterioration. Where unavailable, simple, repeated oropharyngeal examinations should be adopted with assessment of respiratory parameters and ventilatory patterns over time; 4-h wait targets should not apply to these patients as assessment and progress over time are crucial in determining their best and safest management. Early and continued communication between regional burns centres and referring sites is essential to establish optimal management and timing of transfer.

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