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The difficult airway refocused

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The term difficult airway is a concept well appreciated by airway managers around the world.[1–3] In its broadest sense, it can be defined as challenges associated with any of the four methods of oxygenation: tracheal intubation, face mask ventilation, supraglottic airway ventilation, and emergency front-of-neck airway.[4] It is notable that difficulty with any of these methods of management is primarily related to anatomic features which make these techniques procedurally challenging. Thus, as presently understood, the term difficult airway essentially denotes an *anatomically difficult airway*. Technological advances, such as flexible intubation scopes and rigid video laryngoscopes, have greatly improved our ability to safely manage patients with anatomically difficult airways.[5] In addition, improvements in oxygenation methods such as high-flow nasal oxygen and noninvasive positive pressure ventilation have allowed a longer duration of apnoea without desaturation, decreasing the stress of these challenging airways by allowing more time to safely achieve intubation.[6] In this article, we describe the need to refocus attention of the difficult airway to the *physiologically difficult airway*, which is commonly encountered in critically ill patients, as there remains a high incidence of life-threatening complications in these patients despite significant improvements in procedural technology.[7–10]

The recommended management of patients in whom a difficult airway is predicted is to perform awake intubation, which is most commonly accomplished using flexible intubation scopes, and more recently, video laryngoscopes. The Difficult Airway Society published guidelines for awake tracheal intubation outlining indications, suggested equipment and an approach for managing patients with predicted difficult airways.[11] The focus of these guidelines remains with the anatomically difficult airway in which conventional laryngoscopy and tracheal intubation is challenging for the operator. Multiple studies have demonstrated that, in patients with predicted anatomically difficult airways, awake intubation is associated with a high degree of success and safety.[5,12,13] Law and colleagues[12] have found that 1% of patients requiring general anaesthesia at their institution over a 12-year period underwent awake tracheal intubation with a 98% success rate.[12] The complication rate was low and most complications were minor without significant physiologic consequences. Only one patient required an emergency front-of-neck airway and there were no deaths. Another study of 600 awake flexible intubations reported a success rate of 99% and a complication rate of 11%.[13] Most complications were again minor and of little clinical significance. There were no cannot intubate-cannot oxygenate situations, emergency front-of-neck airways, or deaths. Therefore, it can be argued that

with our technological advances and improved skills we have largely mastered the anatomically difficult airway.

It is time now to focus our attention and effort on reducing the substantial risks associated with the *physiologically difficult airway*. The physiologically difficult airway is a term that describes critically ill patients with severely deranged physiology who are at high risk of cardiopulmonary collapse during or immediately after airway management.[7] Though there are many physiologic derangements that are associated with an increase in serious intubation-related complications, the most consequential are those related to hypoxaemia and hypotension. The perils of emergency airway management in the critically ill have been recognised for 25 years, and cardiac arrest rates of 2%–4% have consistently been reported.[8,9,14–16] For example, Schwartz and colleagues[14] evaluated 297 intubations performed in the ICU over an 8-month period and noted that 3% of patients suffered a cardiac arrest within 30 min of intubation. Mort[15] found that of 3035 patients undergoing emergency intubation over a 12-yr period, 2% had a peri-intubation cardiac arrest within 5 min of airway management.[15] Profound hypoxaemia (S_pO_2<70%) was noted in 83% of the patients who suffered a cardiac arrest. A recent study by De Jong and colleagues[9] reported on 1800 intubations performed in 64 ICUs over a 10-yr period and found an intubation-associated cardiac arrest rate of 2.7%. The two physiologic factors that were strongly associated with cardiac arrest were hypoxaemia (odds ratio 3.99) and hypotension (odds ratio 3.41) prior to intubation. Kim and colleagues[16] reported on 2403 intubations in their emergency department and found that 1.7% of patients had a peri-intubation cardiac arrest within 10 min of intubation and most of these patients (78%) had pulseless electrical activity as their initial rhythm. Hypotension before intubation was strongly associated with the development of cardiac arrest (odds ratio 3.67). These figures are likely to be underreported, as they are often recorded post event and are susceptible to disclosure bias. Based on this literature we believe that more emphasis should be placed on identifying and managing patients with physiologically difficult airways.

While there are many reasons why the consequences of the management of patients with physiologically difficult airways are under appreciated, it is likely that clinical perception plays an important role. For example, when there is a death in a patient with an anatomically difficult airway due to a failed intubation, it is immediately clear that the operator's failure to secure the airway was directly responsible for the adverse outcome. In contrast, a death in a patient with a physiologically difficult airway, where intubation is successful, is typically attributed to the severity of the patient's underlying illness and often thought to be unpreventable. However, there is evidence that life-threatening complications such as hypoxemia, hypotension, and cardiac arrest can be reduced with better pre-intubation resuscitation.[17] Deployment of a 10-point intubation bundle in the ICU, that incorporated physiologic optimisation, was found to be associated with a 50% reduction in life-threatening complications.[18] A study of awake hypotensive trauma patients found that those intubated in the prehospital setting had a mortality rate of 15%, but a matched group intubated in the hospital had a mortality rate of 4%, suggesting that delaying intubation for further resuscitation may help to reduce the occurrence of intubation-associated cardiac arrests.[19]

When clinicians perform an airway assessment before tracheal intubation it is routine practice to identify predictors associated with anatomic difficulty. Likewise, during their airway assessment it is important for clinicians to also evaluate patients for physiologic difficulty. The first thing to consider is whether intubation and mechanical ventilation are the right interventions for the patient. For example, a patient with a massive pulmonary embolus and acute right ventricular failure might not tolerate the adverse haemodynamic effects of intubation and may suffer significant clinical deterioration, even cardiac arrest. In a patient such as this, the clinician should consider whether oxygenation and ventilation could be more safely supported with an alternative method such as noninvasive positive pressure ventilation or high-flow nasal oxygen while the primary cause of decompensation is treated.

If tracheal intubation is absolutely necessary, then the timing of the procedure must also be considered. One must evaluate the risks and benefits of delaying intubation for appropriate physiologic optimisation. In critically patients it is frequently beneficial to briefly delay intubation until adequate resuscitation can be achieved. For example, the trauma patient in haemorrhagic shock should receive appropriate volume resuscitation with blood products before induction and tracheal intubation. When faced with a patient with a physiologically difficult airway, one must also consider what the best method of intubation is. In critically ill patients, rapid-sequence intubation is often the first-line approach, as patients are assumed to be not fasted and this technique is associated with a high first pass success rate. However, rapid-sequence intubation may not be the safest option in patients with extreme physiologic derangements. In the profoundly hypotensive patient, the haemodynamic impact of any rapidly pushed induction agent might precipitate complete cardiovascular collapse. In addition, one must consider the impact of a neuromuscular blocking agent on haemodynamics. Cessation of spontaneous ventilation can lead to interruption of venous return and an increase in right ventricular afterload, which may not be tolerated in many critically ill patients. Similarly, patients with severe hypoxaemia and shunt physiology often will not tolerate the apnoea and complete loss of alveolar ventilation associated with rapid-sequence intubation. Consideration should be given to alternatives to rapid-sequence intubation in patients at great risk of deterioration of their oxygenation or haemodynamics. A safer approach, when feasible, may be an awake tracheal intubation using only topical anaesthesia which avoids the apnoea and the negative pharmacologic effects of rapid-sequence intubation. If rapid-sequence intubation is felt to be the best option, then selection of a haemodynamically neutral induction agent, with appropriate dosing, requires careful consideration.

Point-of-care ultrasound is increasingly being used in the critically ill to direct resuscitation decisions.[20] A customised examination can rapidly detect clinically important pathophysiology such as the presence of a pneumothorax, a pericardial effusion, and pulmonary oedema. Additionally, point-of-care ultrasound allows the clinician to make better informed decisions by evaluating global cardiac function, right ventricle size and function, and the inferior vena cava size and collapsibility. This valuable information can augment the ability of the clinician to characterise and mitigate the patient's at-risk haemodynamics.

In patients with overt hypotension or an elevated shock index, haemodynamic resuscitation must be instituted with interventions appropriate for the clinical situation. Patients

who are clinically volume depleted should receive adequate fluid resuscitation before intubation. In patients whose volume depletion is due to acute blood loss, for example patients with traumatic injuries or gastrointestinal haemorrhage, resuscitation with blood products before intubation is indicated. In patients whose hypotension is secondary to vasoplegia, an inopressor, such as norepinephrine, should be administered by continuous infusion. If impaired cardiac contractility is suspected to be a component of the shock state, then an inopressor with more beta receptor activity, such as epinephrine, should be considered. As a physiologic assessment tool, point-of-care ultrasound can assist the airway manager in determining the appropriate resuscitation measures before intubation. While most practitioners are accustomed to using push dose vasopressors as rescue agents for post-intubation instability, pxrevention is likely the better approach and initiation of an appropriate inopressor infusion before intubation should be considered. The administration of vasoactive medications can be safely undertaken through peripheral veins during the peri-intubation period.

The hypoxaemic patient is at risk for bradycardia, further haemodynamic compromise, and cardiac arrest. Regardless of the method of intubation selected, appropriate preoxygenation must be performed before the procedure is carried out.[21] If, after optimal preoxygenation, maintenance of oxygenation is a concern, then utilisation of a technique such as apnoeic oxygenation with high-flow nasal oxygen should be considered.[22,23] In patients who fail to respond adequately (S_pO_2<95%) to administration of an FiO_2 of 1.0 during preoxygenation, use of PEEP to increase the functional residual capacity and reduce ventilation-perfusion mismatch is indicated. In patients at low risk for aspiration, providing gentle face mask ventilation during the induction period of rapid-sequence intubation can help reduce the risk of severe hypoxaemia during intubation.

In 2020, critically ill patients requiring emergency airway management are threatened more by physiologic decompensation than by failed tracheal intubation. To better manage these critically ill patients, clinicians must be more attentive to the physiologic threats associated with airway management and attempt to mitigate these threats with appropriate pre-intubation physiologic optimisation. Achieving optimal preoxygenation before airway management commences is crucial to maximise the safety of intubation. This includes denitrogenation, as well as augmentation, of the functional residual capacity. While apnoeic oxygenation can further extend the safe apnoea time, its benefit in critically ill patients may be less effective depending on the underlying pathophysiology and it should be considered an adjunct to, as opposed to a substitute for, aggressive preoxygenation. In patients with refractory hypoxaemia, significantly extending the safe apnoea time may be impossible and maintenance of spontaneous ventilation with an awake approach should be considered. In patients at significant risk of haemodynamic compromise, resuscitation with appropriate fluids and/or vasoactive drugs is necessary before airway management commences. Judicious selection of an inductionagent, as well as modification of the dose, may also help mitigate post-intubation decompensation associated with rapid-sequence intubation. In select patients, maintenance of spontaneous ventilation with an awake approach should be considered to minimize the haemodynamic impact of intubation.. Cardiac contractility issues, vasoplegia, and right ventricular failure all command special attention with airway management *before* intubation and should not be left to be dealt with *after* the intubation and likely decompensation.

In summary, evidence indicates that the airway community has successfully conquered the anatomically difficult airway, as these patients are managed safely with a low incidence of morbidity and mortality. In contrast, the literature suggests that critically ill patients with physiologically difficult airways continue to suffer serious adverse events, including death, from emergency airway management. It is time now for the airway community to focus our clinical and research efforts on improving outcomes in patients with physiologically difficult airways.

Authors' contributions

JCS, GSP, GK and JMM contributed conceptually to the development of this manuscript, participated in the writing and the revisions of the manuscript.

Declaration of interest

JCS has previously served as a consultant to Verathon. GSP, GK, and JMM declare that they have no conflicts of interest.

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