Perrow developed this as an innovative way of looking at incidents and accidents arising in high-risk environments [3]. He proposed that we look at work in terms of coupling and complexity of interactions. This approach has been applied to anaesthetic practice to break the chain of accident evolution [4].

The headline message from this is that when coupling is tight and complexity is high, the risk of a bad outcome is increased. We suggest that appreciation of coupling and complexity may be used for clinical decision-making in a simple way. We propose that two questions are asked. First, how complex is the situation? A simple count of complexity factors is done. Since a count does not bear linear relationship to risk, a higher count should be treated with due concern. Quite simply, more factors means a bigger chance of emergent outcome and this carries far more risk. Second, with appreciation of the primacy of oxygenation [5], how tight are the couplings between action and outcome? This is a measure of commitment. Whatever airway scheme is considered, if the risk of hypoxia is tightly coupled to any proposed action, risk becomes high, and measures to loosen this coupling should be sought. We appreciate that this approach is essentially approximate, but we think it's worthwhile.

If there are sufficient warnings, a variety of proactive measures are needed, with mobilisation of resources, particularly personnel and equipment. A key consideration should be that when coupling is tight and complexity count is high, the patient's airway should probably be secured awake whenever this is reasonable.

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Failure to THRIVE

Patel and Nouraei report that the THRIVE (Transnasal Humidified Rapid-Insufflation Ventilatory Exchange) technique 'has the potential to transform the practice of anaesthesia' by 'extending the safe apnoeic window' following induction of general anaesthesia and neuromuscular blockade [1]. Their method uses the reported but under-used technique of aventilatory mass flow (AVMF), also known as apnoeic mass movement oxygenation (AMMO) [2], but may have important limitations.

The first of these relates to airway patency following induction of general anaesthesia. For THRIVE to succeed, there must be some retention of anatomical patency between the nasal device and the lungs to allow uninterrupted flow of gas throughout the airway management sequence. Obviously, the nasal passages must be patent. General anaesthesia, however, results in a variable degree of upper airway closure. We note that the authors used application of jaw thrust to manage this. Whist closure was traditionally thought to result mainly from posterior displacement of the tongue, it is more likely to involve the soft palate and epiglottis [3]. There is no clear relationship between depth of anaesthesia and closure ('collapsibility') [4, 5]. The important conclusion is that induction of anaesthesia may result in airway closure. Additionally, application of cricoid force may obstruct the airway [6]. Should closure be complete, the efficacy of THRIVE is lost. We also suggest that accumulations of airway secretions, mucus or blood in the airway are also potential causes of interruption of gasflow. It is important to provide neuromuscular blockade and maintain anaesthesia. The authors used a propofol infusion; if this is not chosen, intermittent administration must ensure protection from awareness.

The second limitation relates to obesity, a prevalent clinical challenge. The authors advise that

THRIVE extends safe apnoea time to 5 min in the 'morbidly obese'. However, this length of safe apnoea time can be achieved using simple nasal cannulae only, at a flow rate of 5 $l.min^{-1}$ with the patients in a 25° head-up position [7, 8] to maintain arterial oxygen saturation at 100% after 4 min [9] or extend saturation > 95% from 3.5 to 5.3 min [10], in subjects with BMI > 35 $kg.m^{-2}$.

We think that THRIVE is an important clinical advance but, like all therapeutic interventions, has limitations, some of which will be unpredictable. THRIVE should be viewed not as an isolated improvement but as part of a sequence of 'optimisation of oxygenation'. We would like to re-emphasise that a combination of methods, allied to the standard of pre-oxygenation monitored using end-tidal concentration, may provide the safest approach during induction. Pre-oxygenation with assisted spontaneous breathing and positive end-expiratory pressure may be of additional benefit in improving oxygenation in the obese patient [11,12], with AMMO methods employed if there is apnoea. These should not detract, however, from other approaches to predictable, problematic airway management, in particular proactive, awake techniques.

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THRIVE – atelectasis, hypercarbia and consent

We would like to congratulate Drs Patel and Nouraei for their breakthrough work in this area of apneic oxygenation, and agree that the technique has the potential to change fundamentally the assessment and management of patients with difficult airways [1]. However, we would like to ask the authors two questions about potential problems with their technique.

During delivery of 100% oxygen, a combination of nitrogen washout and rapid alveolar oxygen absorption leads to alveolar collapse and atelectasis [2]. Did the authors record any increase in the prevalence of postoperative absorption atelectasis after prolonged apneic ventilation?

End-tidal levels do not always reflect arterial blood partial pressures of carbon dioxide, particularly when atelectasis occurs. Could the authors comment on whether they think patients are at risk of significant hypercarbia during prolonged apnoeic ventilation (for example, up to the 19–65 min upper quartile quoted), even if significant oxygen desaturation is not present?

