Reducing variation in tracheostomy care can improve outcomes

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Editor—Polok and colleagues[1] investigated the implications of tracheostomy for individuals with COVID-19 critical illness aged 70 yr or older. They probed whether early ($\leq$10 days) tracheostomy influences outcome across 152 centres in 16 countries. Although potential benefit has been suggested from early tracheostomy,[2] this study provided a much-needed focus on older patients.[1] Whilst this prospective observational study found no association between timing and outcomes, it identified significant variations in patient selection and timing of tracheostomy. We aim to highlight how reducing variation in practice can improve care as part of quality improvement (QI) initiatives.

W. Edwards Deming, often regarded as a founder of QI, observed that, 'Uncontrolled variation is the enemy of quality.'[3] This observation is also relevant to tracheostomy care. A 2015 meta-analysis evaluating the impact of early *vs* late tracheostomy included 13 trials and concluded that timing of (or no) tracheostomy had no significant influence on all-cause mortality in the ICU.[4] Whereas this result persisted in trials with a low risk of bias, the lack of a beneficial effect on long-term mortality may relate to uncontrolled factors. A recent meta-analysis of tracheostomy management during the COVID-19 pandemic identified significant heterogeneity in studies reporting tracheostomy timing, technique, weaning from mechanical ventilation and decannulation, highlighting variations in practice, reporting, and outcomes.[5] Principles adopted from industry can be applied to healthcare to reduce variation and improve care through standardisation and multi-stakeholder engagement. The Global Tracheostomy Collaborative, a QI collaborative established in 2012, brings together multidisciplinary expertise, not only in tracheostomy care, but also QI and change management (www.globaltrach.org).[6]

Variation in outcomes was addressed in a recent tracheostomy QI program that included 20 diverse NHS hospitals included in the Global Tracheostomy Collaborative.[7] Standardised care protocols provided consistency in the care delivered, clinical environment, available equipment, and team dynamics. This guided implementation project reduced mortality, ICU length of stay, and ventilator dependence (outcomes tracked by Polok and colleagues[1]). It also improved quality of life outcomes including speech, swallowing, mental health, and rehabilitation. Improvements were realised through a purposeful reduction in arbitrary variation, a prominent theme in most successful QI initiatives. Local stakeholders identified measures most relevant to their centres and then tracked these interventions at 6-monthly intervals. Significant reduction in variation was evident after 12 months, with an increasing number of interventions and narrowing ranges over time (Fig. 1).

Instituting defined pathways and procedures promotes coordinated care, increases efficiency, and improves outcomes in airway emergencies. Polok and colleagues[1] provide a comprehensive view of pandemic care, shaped by episodic surges and institutional or national mores. Healthcare systems are built on a complex network of care processes and pathways shaped by local experience and culture. The quality of care delivered depends largely on how well this network functions and how well providers collaborate with each other.[8] A wide variation in practices is reflective of the many uncertainties during the COVID-19 pandemic.[9] Much of the international guidance around COVID-19 tracheostomy care has been based on expert consensus opinion.[10] Early recommendations were extrapolated from prior pandemics, laboratory investigations, and preliminary clinical experience. Over the course of the pandemic, however, practices began to converge toward previously accepted norms.[11]

So, what are the root causes of variation in tracheostomy care, and how might they impede high-quality care? Herein lies much of the challenge in existing tracheostomy literature, both with COVID-19 and predating the pandemic; outcome data are collected with far less attention to the processes that gave rise to them. Nonetheless, some contributors are known. During surges, many hospitals were overwhelmed whereas others had unused excess capacity. ICU capacity strain was likely a major source of variation, with accompanying excess mortality in areas of shortages. Resource scarcity may have led to earlier tracheostomy in some sites attempting to free up staff and beds. In other instances, personnel and supply chain disruptions may have delayed tracheostomy. Additional variation may have arisen in availability of personal protective equipment, controversy regarding infectivity at different time points, and clinician theories or biases regarding the expected clinical course of disease.

The work of Polok and colleagues[1] affords invaluable insights into the first step toward improving quality, identifying the presence of variation. The next step involves understanding what drives this variation. Drivers are usually multifactorial and involve a range of individual and system-based factors. For example, early in the pandemic, many patients remained intubated beyond 21 days because of concerns of infectivity.[9] This variation likely had significant survival

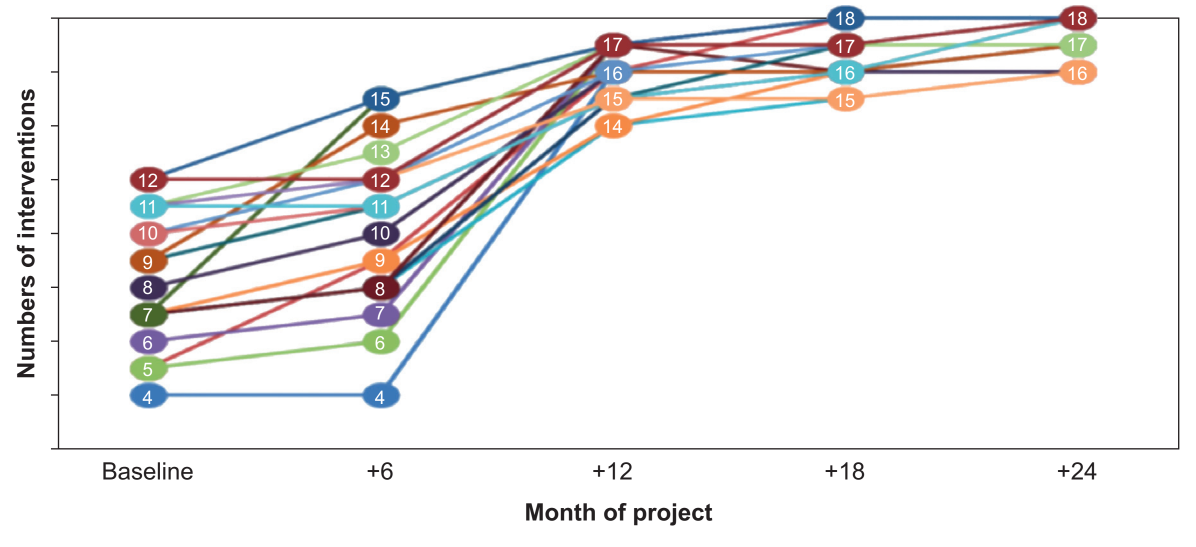

Fig 1. Numbers of interventions implemented during the Improving Tracheostomy Care guided quality improvement programme at 6-month intervals. Colours represent individual sites and numbers are the counts of interventions at that time point. Variation was reduced over the course of the programme.[7]

implications for many patients. Polok and colleagues[1] found that early tracheostomy was associated with reduced ICU length of stay and duration of ventilation, but not increased survival. Randomised studies are needed. Patient-centred perspectives are also critical. For patients with frailty and advanced age, surviving critical illness is only the beginning of the survivorship journey. Some of the most important considerations for older patients relate to rehabilitation, and shorter ICU stay might reduce severity of post-intensive care syndrome.

Polok and colleagues[1] shine a light on recent pandemic experience, illuminating not only the outcomes of tracheostomy in older patients, but also the underlying variation in care practices. The critical observations prime us for the next phase of progress, which requires prospective data collection and collaboration around best practices. The emergence of viral variants and successive waves of the pandemic pose ongoing challenges, but clinicians can continue to improve the standard of care through systematic, evidence-based approaches. Multidisciplinary teamwork and protocols both play a vital role in reining in uncontrolled variation. Critical illness defies simple answers to tracheostomy timing or candidacy; however, collecting data regarding the process of care at participating centres will allow variation to be identified, accounted for, and reduced. Streamlined approaches to data collection can help identify those patients likely to benefit from tracheostomy, and in developing an optimal evidence-based approach to tracheostomy care that is personalised for the patient and standardised for the institution.

Declarations of interest

For transparency, Dr Brenner is President of the GTC and Dr McGrath serves on the Executive Board. We do not believe that either of these roles represent a conflict of interest.

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Protective positive end-expiratory pressure and tidal volume adapted to lung compliance determined by a rapid positive end-expiratory pressure-step procedure in the operating theatre: a *post hoc* analysis

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Editor—Postoperative pulmonary complications (PPCs) occur in up to 30% of patients undergoing major surgery.[1] High airway driving pressure during surgery and changes in PEEP levels resulting in a higher airway driving pressure are associated with increased PPC.[2] Still, none of the predictive scores includes lung mechanical properties as a factor for PPC.[3] On an individual patient basis, airway driving pressure is not representative of the actual driving pressure distending the lung, the transpulmonary driving pressure.[4,5] We have reported that by changing PEEP and determining the change in end-expiratory lung volume (ΔEELV) from ventilator spirometry,[6] lung compliance can be calculated without using oesophageal pressure measurements.[7,8] Here, we reanalysed *post hoc* our previous data[8] to see whether use of a two PEEP-step trial would provide a complete lung pressure/volume (*P*/*V*) curve from end-expiration at clinical PEEP to end-inspiration at the highest PEEP level, and if it could be used to determine the PEEP level with the lowest transpulmonary driving pressure (i.e. the optimal PEEP level).

This is a *post hoc* analysis of raw data from the original validation study of the PEEP-step method,[8] in which 24 patients, age 55 (18) yr; BMI 24.9 (4.0) kg m^{-2}; height 172 (8) cm; and scheduled for gynaecological, thyroid, or parathyroid surgery or thoracoscopy, were included.

The study was approved by the Swedish Regional Research Ethics Committee and registered at ClinicalTrials.gov (NCT02830516). Informed consent was obtained from all patients.

Measurements were performed before start of surgery in supine position during volume control ventilation with a tidal volume of 6 ml kg^{-1} ideal body weight. During PEEP steps of 5–9–5, 5–12–5, and 5–14–5 cm H_2O, ΔEELV was determined as the cumulative difference in expiratory tidal volume before and during the first 15 breaths after changing PEEP.[6,8] In the PEEP-step method, transpulmonary plateau pressure at the highest PEEP level (PLplat) must be estimated as airway plateau pressure minus tidal volume times chest wall elastance, the latter extrapolated from PEEP 5 and 9 cm H_2O. This is a limitation of the PEEP-step method, but evaluation of this estimation shows that estimated PLplat only differed 0.1 (0.8) cm H_2O from the corresponding PLplat calculated from conventional oesophageal measurements performed in the original study.

The equation for the best-fit lung *P*/*V* curve was determined between end-expiration at baseline PEEP, ≈5 cm H_2O, and end-inspiration at PEEP ≈14 cm H_2O. The PEEP level where the transpulmonary driving pressure was lowest (i.e. optimal PEEP) was computed from the equation for the lung *P*/*V* curve. Overall lung compliance (CLtot) was calculated as the change in volume between end-expiration at 0 PEEP and end-inspiration at PEEP 14 cm H_2O divided by the corresponding transpulmonary pressure.

A lung *P*/*V* curve could be obtained by a two-PEEP-step procedure in all 24 patients. The mean CLtot was 97 (59–137) ml cm H_2O^{-1} with an individual variation ranging from values indicative of moderate acute respiratory distress syndrome to emphysema in these patients undergoing elective surgery. In addition, patients with the same overall lung compliance showed completely opposite lung *P*/*V* curves with increasing or decreasing lung compliance when increasing PEEP (Fig. 1).

At the PEEP level with the lowest transpulmonary driving pressure, or optimal PEEP, which was at 9.8 (5.0–15.0) cm H_2O,