principles, illustrated by examples from vascular access. Nevertheless, we still believe that there is insufficient knowledge about such matters in UK practice, and the inherent weaknesses of such retrospective analyses are reinforced in both his and other closed-claim type publications. Further in critical care, there are, to our knowledge, no such publications on legal activity, but we know of many ongoing cases from our expert witness, Coronial, and indemnity practices. We believe that some sort of prospective open access ongoing audit of such practice would be helpful to the profession.

The suggested pattern of national audits after such closed-claim analysis was merely an observation on our part rather than a suggestion that this was any definitive national plan. There are only a limited number of such categorizations available, so it is very likely that such associations will appear to occur even if not planned in advance.

**Declaration of interest**

A.R.B. and M.D.D.B. both act as medicolegal experts, M.D.D.B. is the assistant deputy coroner in West Yorkshire, and J.A. works part time as an adviser in the Medical Protection Society.

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**What is an adequate measure of lung function?**

Editor—Treschan and colleagues\(^1\) set out to determine if setting low tidal volumes for intraoperative mechanical ventilation could affect lung function after surgery. Their hypothesis was that excess stress to lung tissue causes damage. As they state in their introduction, this is not a new concept.\(^2\) Small tidal volumes have often been used in patients with acute lung injury, as a generally accepted means of reducing lung damage. However, the range of stress within the lungs of patients with different conditions, and in normal lungs, can vary considerably.\(^3\) Studies similar to the study of Treschan and colleagues have shown previously that smaller tidal volumes are associated with less inflammation, even in patients with normal lungs.\(^4,5\) However, Treschan and colleagues\(^1\) conclude that low volumes ‘do not improve post-operative lung function’, although they have used a crude measure of ‘lung function’ unlikely to indicate damage to lung parenchyma.

Their conclusion misrepresents ‘lung function’ tests. Forced vital capacity is one of the most widely used ‘lung function’ tests in medicine. Measurements from a forced vital capacity manoeuvre, such as expired volume in 1 s, or mid-expiratory flow, are used to assess a variety of conditions that affect the chest wall, lung airways, and parenchyma, the most common being asthma and emphysema. In many subjects, these values often co-vary strongly: the FEV\(_1\) depends on the preceding inspiration, essentially because the flow out of the airways is limited by the elastic properties of the lung and airways. Indeed, the ‘effort independence’ of the test, if done properly, is the prime reason why, in standardized circumstances, it is a good test of ‘lung function’. The factors that affect the value of FVC can be sensibly divided into those that impair chest wall movement, including the ribs and the respiratory muscles, and those affecting the lung airways and parenchyma. Conditions such as respiratory muscle weakness can reduce vital capacity, and may have secondary pulmonary effects. For example, chest wall restriction, as occurs after abdominal surgery, affects lung function as a result of changes in chest wall position and movement.\(^6\)

A vital capacity manoeuvre requires full patient cooperation and maximal effort. Indeed, a classic textbook on lung function tests includes a cartoon of the technician shouting at the patient!\(^7\) For many years, abdominal surgery has been known to have substantial effects on vital capacity,\(^8\) because both inspiratory and expiratory muscle force are reduced.\(^9\) Beecher\(^9\) used the powerful expression ‘crippling of the respiratory mechanics indicated by decrease of vital capacity’ and wrote: ‘A consideration of how vital capacity is obtained should make this evident. The patient is required to take the deepest possible breath and then to expire as completely as possible. This procedure requires great cooperation on the part of normal persons while in the sick it demands more than can always be obtained’. The substantial effect of upper abdominal surgery in reducing vital capacity, by up to 70% or so, is mediated by reduced ability or willingness to undertake the large muscle effort, and by reduced chest wall movement, both of which are needed to perform the test. Impairment of deep breathing and coughing has been related frequently to the development of pulmonary complications.

Because restriction of chest wall movement can be related to pain, Bromage\(^10\) suggested that the ability to perform the vital capacity manoeuvre could be used to measure analgesia after surgery. Thus, a ‘lung function’ test became a measure of pain, and perhaps even personality.\(^11\) Even after obtaining satisfactory analgesia, vital capacity remains substantially reduced after abdominal surgery.\(^12–14\) The possibility that this test could provide a suitable measure of possible subtle pulmonary damage is remote, when one compares the relative muscle forces needed to expand lung tissue with those required to perform a forced vital capacity manoeuvre.\(^15\)

What was the reason to choose such an outcome for the purpose of this study? As evidence that mechanical
ventilation can reduce ‘lung function’, the authors cite a recent study of patients having back surgery, where vital capacity was reduced by about 5%, and suggest that the choice of anaesthetic agent can alter such vital capacity changes. They cite a further study of patients having vaginal surgery, using either general or regional anaesthesia, where again the changes in vital capacity were only about 10%. Such effects are not comparable with the large changes in vital capacity that occur after upper abdominal surgery. In discussion, the authors suggest that lung function is reduced after abdominal surgery by ‘reduced ventilatory muscle activity, diaphragmatic dysfunction, and decreased lung compliance’, citing a study by Dureuil and colleagues. However, this paper did not report values of lung compliance, and the index of ‘dysfunction’ of the diaphragm used in this paper is controversial. Thus, the choice of primary outcome measure in this study is ill-suited to detecting evidence of lung damage. The authors have chosen a measure of chest wall movement that is substantially affected by the presence of an upper abdominal wound. For decades, an upper abdominal incision has been known to have a substantial effect on the capacity to take in a large breath in, and force it out. Any effect on lung mechanics caused by mechanical ventilation will pale into insignificance.

The authors suggest that their study was of sufficient size to detect a difference of 200 ml, relative to a forced vital capacity after surgery of 2 litre. This value was chosen on the basis of data from studies of patients after vaginal surgery and patients who had open or laparoscopic cholecystectomy. Neither of these patient groups resemble the patients studied, where the vital capacity was reduced from 3 litre to about 1.7 litre. Epidural analgesia was planned for the patients they studied, and achieved in 83 of the 101 patients. Forced vital capacity could be measured in 58 patients after surgery and in 54 patients at 24 h. From these values, a ‘time weighted’ average was calculated, although the exact procedure used for this calculation is not given. None of the secondary measures, many of which were not postoperative, were powered to show a difference, and several were inappropriately tested for significance since they were outcomes of the planned intervention. The evidence in this paper is insufficient to support the conclusion of the title. A better conclusion would be that no difference is not the same as the same.

**Declaration of interest**

None declared.

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**Reply from the authors**

Editor—Postoperative pulmonary complications are serious clinical problems and patients after upper-abdominal surgery are at especially great risk. Dr Drummond clearly explains the impact of postoperative pulmonary impairment,