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Complete List of Authors:	Lumb, Andrew; St James's University Hospital, Anaesthetic Dept Yeung, Joyce; of England NHS Foundation Trust, Department of Anaesthesiology
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A small step in the right direction for reducing postoperative pulmonary complications

A. ~~ndrew~~ B. Lumb[1]* and J. Yeung

[1]Department of Anaesthesia, St James's University Hospital and~~,~~ Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds ~~LS9 7TF~~, UK

~~Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds LS2 9JT, UK.~~

~~Joyce Yeung~~

[2]Warwick Medical School, University of Warwick, ~~Gibbet Hill Road,~~ Coventry ~~CV7 4AL~~, UK

and

Department of Anaesthesia and Critical Care, Heart of England NHS Foundation Trust, Birmingham ~~B9 5SS~~, UK

* Corresponding author. E-mail: a.lumb@leeds.ac.uk

Only 12 years after the first successful public demonstration of general anaesthesia ~~(GA)~~ in 1846, one of the first adverse effects to be described was reported by John Snow: '*If the inhalation is continued the breathing is rendered difficult, feeble, or irregular, and is sometimes performed only by the diaphragm, whilst the intercostal muscles are paralysed. If the dose of chloroform is gradually increased after these effects are produced, the breathing entirely ceases*'.[1] Ever since ~~then~~ the fact that ~~GA~~ anaesthesia can cause postoperative chest complications has been widely accepted by anaesthetists, so it is surprising that only relatively recently have serious efforts been made to understand the aetiology of this common problem, with a view to being able to their prediction and prevention ~~chest complications~~. The term post-operative pulmonary complication (PPC) has become widely adopted and describes a single outcome measure representing a disparate collection of complications~~,~~ linked only by a common organ of origin. PPCs are more~~-~~ common than cardiovascular~~-~~ complications, have a significant impact on outcome measures such as length of hospital stay, increase healthcare costs, and when severe are associated with increased mortality.

Current knowledge of PPCs suggests they are multifactorial in origin.[2,3] The well known physiological changes associated with ~~GA~~ anaesthesia such as reduced functional residual capacity, disturbed ventilation-perfusion relationships and development of atelectasis ~~may~~ can continue into the post-operative period when surgical trauma, pain and the stress response to surgery exacerbate these physiological abnormalities leading to pathological conditions. Artificial ventilation during ~~GA~~ anaesthesia remains an ~~significantly~~ unphysiological process, applying pressures to delicate lung tissue that are several times higher than physiological breathing, potentially causing physical lung damage or inflammatory changes. There are over 50 factors that have been shown to be predictors for developing a PPC,[3] which can be categori~~z~~ed ~~into~~ as those relating to the patient, the procedure, or laboratory investigations. Approximately half of these are potentially modifiable.[3]

Many strategies to prevent PPCs are described, but good quality evidence of outcome benefits for most of them remains elusive. Take preoperative smoking cessation as an example of a non-invasive intervention that really should work. Studies in the 1980s of patients having cardiac surgery paradoxically suggested that stopping smoking for less than 8 weeks pre-operatively was associated with a ~~worse~~ greater respiratory complication risk than keeping smoking until the day before surgery.[4] Subsequent work has convincingly challenged this finding such that current evidence suggests that stopping smoking pre-operatively does indeed reduce ~~the~~ PPC risk, and that the longer the period of effective smoking cessation the better the outcome.[5] However there remains varied opinion on how many weeks are required for this benefit to become clinically significant, or whether the number of pack-years smoked before quitting affects the benefit. In the most recent and widely used score for predicting PPC risk smoking did not prove to be an independent predictor, while recent upper respiratory tract infection or a preoperative oxygen saturation <96% on air did.[6] This suggests that in the absence of these two clinical findings a smoker's risk is the same as for a non-smoker.

A similar uncertainty exists around artificial ventilation during anaesthesia. Use of a 'protective ventilation' strategy of low tidal volume, moderate positive end-expiratory pressure (PEEP), pressure limited ventilation and recruitment manoeuvres, as used for many years in lung-injured patients in intensive care, is now generally agreed to reduce PPCs.[7] But there is less agreement on the ideal settings for these ventilation components, or how they should be modified in specific patient groups such as those with pre-existing lung disease, morbid obesity or during one-lung ventilation ~~(OLV)~~. For example pressure-controlled ventilation as part of protective ventilation has shown some benefits in some of these challenging patient groups such as one-lung ventilation ~~OLV~~[8] and obesity.[9] Conversely, a recent observational study involving more than 100 000 patients having varied surgical procedures found a significant benefit for volume-controlled ventilation in reducing PPC occurrence.[10] Despite these uncertainties on the finer details of how best to prevent PPCs there is general agreement that some form of intraoperative protective ventilation is

beneficial,[11,12] but surveys of actual practice show adoption of this approach to be slow.[13,14] There is also controversy on the optimal inspired oxygen concentration to use in the perioperative period, with most anaesthetists advocating use of the lowest inspired concentration to avoid atelectasis and higher mortality,[15] in contrast to a World Health Organisation (WHO) recommendation of 80% inspired oxygen to prevent surgical site infection,[16] a recommendation that has been questioned.[17]

A clearer understanding of potential ways of preventing PPCs is therefore required, but two problems are impeding progress in this area. First is variation in the components of ventilation 'bundles' used by studies in this area. A clear example is the lack of agreement on what constitutes an effective lung recruitment manoeuvre, with three quite different techniques used in different studies.[18] Second, and in our opinion more fundamentally, is the lack of agreement on what constitutes a PPC. Considering the large number of individual patient events that may be counted as a PPC, use of composite measures is unavoidable to obtain large enough event rates to allow interventional studies. But the lack of agreement on which composite to use is currently a problem, both in terms of facilitating research and on the implications of those studies for patients. For example, consider two studies looking at PPC incidences with and without muscle relaxant usage. In the first a PPC was recorded if oxygen saturation to fell to <90% for one 1 minute in the 20 minutes after extubation,[18,19] while in the second a diagnosis of one or more of respiratory failure, pulmonary oedema, tracheal reintubation, or pneumonia was required to be counted as having a PPC.[19,20] The implications for patients from these two studies are quite different.

An international initiative in peri-operative medicine is beginning to address this second problem. In 2015 a joint taskforce of the European Society of Anaesthesiology and European Society of Intensive Care Medicine published definitions for 22 individual adverse respiratory events and some composite measures for PPCs.[20,21] On page @@@ of Inthis month's *British Journal of Anaesthesia* Abbot et al.and colleagues,[22] on behalf of the Standardized Endpoints for Perioperative Medicine (StEP) collaboration, have continued this work and reached a consensus for a definition of PPCs in an attempt to further unify research in this

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area.[21] Agreed definitions were reached by a systematic literature review followed by the now widely-used Delphi process including three rounds with 75 expert participants in round two. The group accepted existing definitions for pneumonia and acute respiratory distress syndrome, the latter being combined with an adapted definition of re-institution of mechanical or non-invasive ventilation to define postoperative respiratory failure. Perhaps indicative of the challenges of existing definitions, the taskforce was unable to agree on a~~n acceptable~~ previous definition of PPCs and instead proposed a new definition despite the abundance of published studies that have examined post-operative pulmonary complications.

The paper is to be applauded for attempting to end the plethora of definitions used for a PPC, and hopefully this will be accepted by the PPC research community for future studies. For the first time, the PPC definition described introduces the concept of severity (classified as mild, moderate or severe) rather than the all-or-none mostly used previously. This will hopefully avoid future examples like that above where patients with a brief desaturation in ~~PACU~~ recovery or a prolonged stay in intensive care are both classed as simply having a PPC for research purposes. Unfortunately, in order to achieve a clearly defined set of criteria for a PPC, Abbot ~~et al.~~ and colleagues excluded many complications affecting the respiratory system ~~which~~ that are seen on a daily basis in most hospitals. These include pulmonary thromboembolism, bronchospasm, cardiogenic pulmonary oedema, pleural effusion and pneumothorax, many of which were included in various previous definitions. The justification for these exclusions was to avoid including complications that can only be identified by specific screening of all study participants, such as pulmonary thromboembolism, and a desire to keep the results applicable to perioperative care of a mixed surgical population rather than focussing on specific technical complications of surgery. This is fine, but having excluded so many common complications previously classed as PPCs, the incidence of PPCs using these new criteria is likely to be much lower than previously cited. Furthermore, can they really be called PPCs if all these critical complications involving the respiratory system are excluded?

This work also provides a welcome example of perioperative medicine on an international scale: the group involved in agreeing the new definitions included an impressive collaboration of experts from ten countries and three continents. This not only gives the work international credibility but also makes wider acceptance of the definitions more likely, so hopefully improving the performance and interpretation of future PPC research. As with all new definitions, the validity, reliability and responsiveness of the proposed standardised endpoints for pulmonary complications will have to be tested in the real world. The systematic and transparent consensus process will lend it strength and credibility to the clinical community.

This example of international collaboration in peri-operative medicine is an overdue attempt to tackle a common and hazardous complication of general anaesthesia. Since 2015, the StEP Collaboration has been working towards standardised endpoints for perioperative patient outcomes.[22] An agreed definition has the potential to advance research in PPCs, but there is still a long way to go before we fully understand PPCs and can finally start to change practice to prevent them.

Authors' contributions

AL and JY worked together to draft, produce and approve the manuscript.

Declarations of interest

None declared

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