

Deaths associated with anaesthesia – 65 years on

'We cannot change the past: we can only take action in the present and, therefore change the future.' — Ken Poirot, author

In 1949, the Council of the Association of Anaesthetists announced the launch of an 'investigation of deaths associated with administration of anaesthetics' [1]. Two articles describing specific complications associated with death were published during the investigation [2,3] but the complete report, 'Deaths associated with anaesthesia' by Edwards et al. [4], was published in *Anaesthesia* in 1956 and is this month's 'Contemporary Classics' publication.

There are several features of the manuscript which seem remarkable to us in the present day. The paper is verbose (27 pages), the prose now seems somewhat archaic and the gender bias in the specialty at the time is clear, as exemplified in the final sentence of the first paragraph. However, the investigators were resourceful and innovative when pioneering such audit. They recognised the importance of anonymity if deaths were to be reported willingly, and the names of both the anaesthetist and the patient remained unknown to them. The authors also had to invent a system for assessing patient fitness, because the now ubiquitous American Society of Anesthesiologists' (ASA) physical status scoring system was not adopted until 1962 [5].

The investigation was the first proper attempt to audit deaths related to anaesthesia in the UK, and the first to analyse specifically the causes of these deaths and classify them. Clearly, the study could not estimate the incidence of death because self-reporting was incomplete (the authors acknowledge that there was wide variability in the number of deaths reported by different hospitals and that an unknown number of deaths were not reported), and the numbers were too small to provide reliable information on the relative safety of different agents or techniques. The factors making a significant contribution to death were classified under 22 headings (Table 1) and the causes

of each were described in detail. The authors considered that 598 (59.8%) of deaths investigated were due wholly or significantly to anaesthesia.

A striking feature is the difference between anaesthetic practice during the study period and modern anaesthesia. More than 10% of the deaths were categorised as "*Circulatory failure immediately following intravenous barbiturate injection*". Six deaths occurred during chloroform anaesthesia, three in healthy patients. Twelve died during administration of trichloroethylene. Overdosage with ether is mentioned. The indiscriminate use of carbon dioxide was a frequent component of the anaesthetic technique and lethal in a number of cases. There was a death caused by an explosion and many related to deficiencies in immediate postoperative care.

It must be understood, however, that during the study period most anaesthetics were administered by inadequately trained or self-taught doctors, often house officers or trainee surgeons, using primitive, frequently home-made or self-adapted equipment, a very limited range of drugs, and monitoring consisting of a finger on the temporal pulse, intermittent observation of the patient's colour and an occasional measurement of blood pressure using a mercury sphygmomanometer. Assessment of ventilation was by visual inspection. One death was caused by attachment of a nitrous oxide cylinder instead of oxygen, as non-interchangeable valves had not yet been introduced.

In the USA, Beecher and Todd [6] reported in 1954 that, in a series of almost 600'000 anaesthetics given over a 5-year period from 1948 to 1952 (overlapping the Association of Anaesthetists investigation) in 10 University hospitals, only 10.4% of anaesthetics were administered by medically qualified anaesthetic specialists; 40.3% were given by anaesthetic residents, 21.2% by nurses (not applicable in the UK), 20.3% by surgeons and 7.8% by others, including 4% by medical students. Tracheal intubation was employed in just 13.4% of general anaesthetics. Controlled or assisted ventilation was used in 4.5% of inhalational anaesthetics. The authors concluded that 1.1% of all 7977 surgical patients who died did so primarily because of their condition, 0.07% as a result of

surgical error and 0.06% as a result of general, local or regional anaesthesia (as a primary or contributory factor). The mortality rate was highest for anaesthetic specialists and lowest for nurses, but this was almost certainly because the specialists treated patients with the highest risk. The overall risk of death from anaesthesia at that time was 1 in 2100, but the risk increased to 1 in 370 if given curare ('curare' encompassed all muscle relaxants). This was not related, at the time, to any clear identifiable factor but most patients given curare breathed spontaneously, often without tracheal intubation and reversal with an anticholinesterase was not reported and probably unlikely.

The importance of this innovative report by Edwards et al. [4] was twofold. First, identification of factors contributing to deaths associated with anaesthesia was relevant to anaesthetists at the time and would have reinforced the importance of anonymised reporting. Secondly, and in our view of much more significance, was the recognition that audit of outcome was of immense potential value in trying to identify and, thereby, reduce risks of various aspects of anaesthetic practice.

A subsequent publication on 600 further deaths reported to the Association of Anaesthetists in 1964 [7] found that the nature of the causes of death had changed since 1956, perhaps as a consequence of the earlier audit; hypovolaemia had replaced regurgitation as the commonest single cause, although a number of the other causes were similar.

The concept of audit was developed further in the 1970s. In 1977, a grant was awarded to the Association of Anaesthetists by the Nuffield Provincial Hospital Trust for the design and development of a confidential enquiry into deaths associated with anaesthesia. This culminated in a landmark report 'Mortality associated with anaesthesia' by Lunn and Mushin [8]. On the basis of opinions that anaesthesia had played some part in the death, expressed by either the anaesthetist or the surgeon involved with the case, a detailed questionnaire was completed by the anaesthetists involved in 365 deaths which occurred within 6 days of surgery amongst a population of approximately 1.1 million operations. This was then scrutinised by two assessors who decided the extent to which the whole process of anaesthesia had been involved.

Although 1 in 166 (0.6%) patients died within 6 days of a surgical operation, only 1 in 10'000 died totally as a result of anaesthesia. However, the number of deaths totally attributable to anaesthesia was in the region of 280 per year in the UK and the majority of these were probably avoidable. In a much larger number, 1800 deaths (1 in 1700 or 0.06%), anaesthesia may have played some part and these too could, in large measure, have been avoided. The events which caused these deaths, and their incidences, had not changed much over the previous 30 years. The mistakes which occurred did so in the hands of all grades of anaesthetist. Trainee anaesthetists were all too often left unsupported by specialists for supervision, and by other staff for assistance. The provision of essential monitoring instruments was inadequate and, even when available, they were not always used. Clinical anaesthetic records were often not kept, inaccurate or incomplete. There appeared to be insufficient consultation between operation team members concerning various aspects of the operation including the procedure and extent of surgery, timing, pre- and postoperative care and prognosis. A high proportion of patients suffered from co-morbidities unrelated to surgery and these were often not optimised. This increased the risk but the implications for the anaesthetist were often ignored. There were still hospitals where proper recovery facilities were not available. There was little evidence that anaesthetist fatigue played much part in these deaths, although working hours were typically long and unregulated. It was clear that anaesthesia might have been a contributory factor in deaths which occurred more than 24 h after surgery. Due to the interplay between and the difficulty of assigning causative factors in postoperative deaths to anaesthesia or to surgery, it was concluded that future epidemiological studies should be combined ones between specialties.

This conclusion led Lunn to liaise with a surgeon, Brendan Devlin. With the support of the Association of Anaesthetists and the Association of Surgeons of Great Britain and Ireland, sponsored by the King's Fund and Nuffield Provincial Hospitals Trust, they reviewed 30-day peri-operative deaths in three regions in England and published the first report of 'A Confidential Enquiry into Perioperative Deaths' in 1987 [9]. There were 410 deaths (14.1% of all deaths) attributed in part to

anaesthesia, but only three (0.1%) in which anaesthesia was the only factor. The presenting surgical condition (34.5% of deaths) and intercurrent disease (21.8%) were the most common causes of death.

It was recognised that peri-operative deaths were an important public health issue, and the National Confidential Enquiry into Peri-operative Deaths was established in 1988. In its first report [10], dealing with paediatric anaesthesia, the importance of specialist paediatric anaesthetists was emphasised, as was the value of local audit meetings. Since the report, there have been 50 further reports dealing with various aspects of surgical and anaesthetic care [11]. The purposes of all these enquiries were to try to improve the clinical practice of surgeons and anaesthetists, and to identify deficiencies in hospital systems which impacted on the ability of medical staff to attain the highest standards.

National Audit Projects in anaesthesia were initiated by the Royal College of Anaesthetists (RCOA) in 2003 to study anaesthesia-related complications of low incidence that are potentially serious for patients and important to patients and anaesthetists. Their management was taken over by the NIAA Health Service Research Centre in 2011. The results of six projects have been published, and the wealth of information generated has important implications for safety and practice [12].

Since the publication of the paper by Edwards et al. [4] in 1956, the nature of anaesthetic practice has changed dramatically. Safer drugs have been introduced, standards of training, practice and monitoring have improved and, in the last 25 years particularly, UK hospitals have been re-equipped with modern anaesthetic equipment and monitoring instrumentation. The concept and involvement of anaesthetists in the whole peri-operative care process, enhanced recovery and evidence based peri-operative medicine have positively impacted the quality of care. The increasing amount of litigation against hospitals caused the then National Health Service Litigation Authority (now NHS Resolution) to ensure that safety standards were improved in many areas by hospital managers. The requirements to have evidence of continuing medical education (CME) and annual appraisal were

instituted to minimise the risks of incompetent or out-of-date staff continuing to practise. The Association of Anaesthetists publish standards of care on various topics to improve patient care and safety. Training and qualifications of anaesthetic assistants have been regulated. Anaesthesia should now be safer.

Many other anaesthesia and surgical mortality studies have been performed [13-16]. What has become increasingly clear is a pattern of decreasing numbers of deaths associated with anaesthesia in healthy or reasonably healthy (ASA grades 1 or 2) patients but an overall death rate which has remained at about the same value as in 1954, when the Beecher and Todd study [6] was published. This static position in overall deaths caused or contributed to by anaesthesia has resulted from a demographic shift, whereby an increased number of older and higher risk patients are receiving anaesthesia because they are now being offered major, complex and emergency operations which would not have been contemplated in the 1950s and 1960s [17-19].

As with every generation, these anaesthetists would have felt on the cutting edge of technology and pharmacology. What will the clinicians of 2085 think of our practice? Advances in the medical treatment of disease will almost certainly lessen the need for surgery/anaesthesia and, as we are already seeing, there will be much greater emphasis on perioperative medicine. Robotics will supersede technical skills (sorry DAS) for both us and surgeons, and we should have much better techniques to monitor what anaesthesia actually is i.e. consciousness and nociception. Perhaps we will have unlocked the secrets of hibernation and organ protection. If anything, patients will be even older, although less frail. As the cause of peri-operative deaths is often multifactorial and the collective responsibility of surgery and anaesthesia, we are all responsible. We have seen that even simple and inexpensive changes in practice can have a major impact on safety e.g. the WHO surgical safety checklist; and more integration between surgery and anaesthesia is going to be important. *Anaesthesia* is already paving the way with their collaboration with the British Journal of Surgery in 2020 on advances in peri-operative care (<https://associationofanaesthetists->

publications.onlinelibrary.wiley.com/toc/13652044/2020/75/S1). There is no doubt, however, that critical reflection on our patient care will remain just as important. Although a relatively small audit by modern standards, this month's 'Contemporary Classics' manuscript was a seminal paper which has inspired many clinicians to identify, investigate and quantify the causes of deaths associated with anaesthesia and other aspects of safety in our specialty and pave the way for vast improvements in peri-operative care. *'The only real mistake is the one from which we learn nothing.'*
- Henry Ford.

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Table 1. Classification of factors identified as contributors to deaths associated with anaesthesia death by Edwards *et al.* [4].

Regurgitation and vomiting

Obstetrics

Circulatory failure immediately following intravenous barbiturate injection

Postoperative respiratory obstruction due to pharyngeal relaxation

Chloroform

Trichloroethylene

Apparatus

Pre-operative upper respiratory tract obstruction

Endotracheal anaesthesia

Convulsions

Respiratory obstruction due to aspiration of blood during or after nose and throat operations

Antidotes, analeptics and stimulants

Induced hypotension

Overdosage

Underdosage

Inadequate ventilation

Epidural analgesia

Spinal analgesia

Premedication

Techniques associated with suboxygenation

Bronchospasm

Inadequate resuscitation