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REFERENCES

1. Zuberbuhler JR. *Clinical Diagnosis in Pediatric Cardiology*. New York: Churchill Livingstone, 1981: 31, 46-50.
2. Keith JD, Rowe RD, Vlad P. *Heart Disease in Infancy and Childhood*. 3rd ed. New York: Macmillan, 1978: 4-6, 418-451.
3. Nadas AS, Fyler DC. *Pediatric Cardiology*. Philadelphia: WB Saunders, 1972: 405-431.
4. Upshaw CB. Congenital coronary arteriovenous fistula. *Am Heart J* 1962; **63:** 399-404.
5. Stone FW, Formanek A, Kaplan EL. Coronary artery fistula. *Clin Pediatr (Phila)* 1977; **16:** 817-819.
6. Sanchez HE, Barnard CN, Barnard MS. Fistula of the sinus of Valsalva. *J Thorac Cardiovasc Surg* 1977; **73:** 877-879.
7. Mair D, Ritter D. Truncus arteriosus. In: Moss A, Adams F, Emmanouilides G, eds. *Heart Disease in Infants, Children and Adolescents*. 2nd ed. Baltimore: Williams & Wilkins, 1977: 417-429.

Obstruction of a breathing circuit

A case report

J. A. ROELOFSE, E. A. SHIPTON

Summary

Preventable mishaps resulting from human error contribute to anaesthetic risk, as demonstrated in the case report presented. The incidence of anaesthetic-associated deaths has fallen steadily since 1935, and general anaesthesia is now a very safe procedure, provided the anaesthetist takes the requisite precautions.

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Case report

A 6-year-old White child was admitted to hospital for nasal cauterization under general anaesthesia. Premedication consisted of trimeprazine tartrate and methadone orally.

The ECG and pulse rate were monitored continuously throughout the peri-operative period. Induction was by 60% N_2O : 40% O_2 and halothane 3%. The anaesthetic circuit consisted of a Jackson Rees modification of an Ayre's T-piece. The fresh gas flow was at least 220 ml/kg to prevent rebreathing. Two endotracheal tubes (5,0 mm and 5,5 mm) were at hand for intubation. The concentration of halothane was gradually decreased to 2%. An intravenous line was inserted and atropine 0,12 mg followed by suxamethonium 15 mg was given intravenously, and a 5,0 mm endotracheal tube inserted. The tube was attached via a Magill's connection to an Ayre's T-piece. Increased resistance was felt in the breathing bag and the patient could not be ventilated. A defective or occluded endotracheal tube was suspected; the patient was extubated and re-intubated with a 5,5 mm tube. No further problems were encountered with ventilation and the further peri-operative course proved uneventful. The initial endotracheal tube and the Magill's connection were carefully inspected. The Magill's connection was found to be totally occluded by tissue paper deep within its elbow.

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Discussion

Tissue paper was probably inserted during the cleaning of the Magill's connection. Fortunately the obstruction did no harm, but this case illustrates the fact that preventable mishaps due to human error add to the anaesthetic risk.

Studies of anaesthetic safety

The history of the pursuit of a safe anaesthetic technique is a long one, and Joseph Clover was himself intensely interested in this. When John Snow died in 1858, Clover became 'the leader of the second generation of anaesthetists and an expert clinician who laid the solid foundations for the safe practice of anaesthesia'.[1] Up to 1871 Clover had administered 7 000 general anaesthetics, with chloroform as an inhalational anaesthetic agent, without a single death. This is a remarkable record of safety since at that time he had been pioneering the anaesthetic techniques.

Sykes[2] tabulated the number of anaesthetic-related deaths in England from 1846. The increase in mortality rate up to 1940 was probably due to the increase in the number and variety of surgical procedures. The peak incidence occurred between 1940 and 1950, which were the early years of modern anaesthesia and specialization. In 1954 Beecher and Todd[3] investigated anaesthetic-associated deaths during 599 548 general anaesthetics, and concluded that 7,5% of deaths were due to 'gross anaesthetic mismanagement'. Edwards *et al.*[4] emphasized the importance of the human factor in 83% of 589 deaths during general anaesthesia. In 1961 Dripps *et al.*[5] also focused attention on deaths 'attributed

to anaesthesia', and found that human errors played a significant role in 87% of a series of 80 deaths during general anaesthesia.

Clifton and Hotten[6] provided an insight into 162 anaesthetic-related deaths during 205 640 general anaesthetics during the years 1952 - 1962. The high mortality rate in the age group 0 - 20 years was probably due to the high-risk surgery performed as 43,2% of the operations were intrathoracic, 26,5% intra-abdominal and 10,7% intracranial. The contributions of general anaesthesia, surgery and the physical condition of the patients towards mortality were noted and estimated as 1 : 3 955 for the anaesthesia, 1 : 2 311 for surgery and 1 : 1 996 for the patient's illness. The incidence depends considerably upon the surgical population — a unit dealing with cardiovascular, neoplastic or intracranial disease can expect a higher mortality incidence. Clifton and Hotten[6] also made another interesting observation. Where anaesthesia was a contributory factor, death occurred within the first 30 minutes after induction; however, 40% of deaths took place after the anaesthetic had been completed. Most of these patients became progressively hypotensive during prolonged operations.

In 1971 Scurr[7] showed that the decrease in the number of anaesthetic-associated deaths relative to the number of general anaesthetics administered began in 1935 and was due to better education in anaesthesia and to improved anaesthetic techniques.

In 1979, Utting *et al.*[8] reviewed the 602 anaesthetic incidents reported by the Medical Defence Union in England between the years 1970 and 1977. Some of these were relatively minor (for example, damage to teeth), but there were 277 deaths and 108 cases of neurological damage. Faulty anaesthetic technique caused 43% of deaths, the most common problem being related to endotracheal intubation.

The characteristics of human error and equipment were examined by Cooper *et al.*,[9] using critical incidence analysis technique. Information about preventable anaesthetic mishaps was collected through interviews with many anaesthetists, and these varied in degree from malfunction of laryngoscopes to breathing circuit disconnections leading to deaths. They showed that the human factor played a role in 82% of these incidents and equipment failure in 14% of cases. Other factors frequently associated with incidents were inadequate communication among personnel, haste or neglect of precautions, and distraction. Communication between anaesthetist and surgeon is of great importance and it must never be forgotten by the surgeon that the anaesthetist also has certain rights, namely 'the right to be informed, the right to encourage, the right to warn'.[10] These are sometimes overlooked by the surgeon who may embark on a procedure from which there is no return without letting the anaesthetist know what he is doing or what he proposes to do.

Even during the postoperative phase in the recovery room, the human factor influencing mortality should not be overlooked. Respiratory obstruction can occur suddenly and must be anticipated. Postoperative deaths may also occur when facilities for patient management are inadequate.

It is not always possible to obtain accurate statistical data about anaesthetic-related accidents due to human error because the cause is often unknown, less serious mishaps are not reported, and the patient's condition (for example, in terminal carcinoma) may make death almost inevitable.

Prevention of anaesthetic-related deaths

One simple yet effective way to minimize mishaps is the systematic use of checklists, a variety of which are available for anaesthetic machines. Foster and Roelofse[11] have drawn up a checklist for the evaluation of an anaesthetic machine before use. One specific recommendation is to breathe through the system and to check the valve and movement seating; this will usually give a good indication of any obstruction. Failure in pipeline systems can still play an important role in anaesthetic mishaps, even after nearly half a century of piped gas supplies to operating theatres. Errors in filling gas cylinders have also occurred[12] and an index safety system cannot prevent every mistake;[13] it therefore remains important to check anaesthetic apparatus personally. Reliance on other people is at best unwise and at worst negligent. Endotracheal or nasotracheal tubes as well as catheter mounts and connections must be checked for obstruction. After intubation the following measures are important: (*i*) ensure that the tube is in the correct position by observing the chest wall movement and by using a stethoscope; (*ii*) should obstruction be suspected, remove and replace the tube at once; and (*iii*) anticipate the possibility of obstruction in the breathing circuit.

It is essential to have more than one endotracheal or nasotracheal tube at hand for children. A choice of tubes of different sizes should be available.

The problem of cardiac arrest while the patient is under the care of the anaesthetist, though small, remains. Fortunately sophisticated monitoring apparatus is now available to aid human observation. Boba[14] stated this clearly: 'One should realize, indeed develop a firm conviction, that our natural sensors are quite inadequate for the task of acquiring information from an anaesthetized patient.' An anaesthetist who, finger on pulse, knows that his patient is doing well represents nothing but a dazzling display of conceit and ignorance.

No one can seriously doubt that in these times death is an uncommon complication of anaesthesia and that the quantitative use of anaesthetic deaths as an indication of our anaesthetic risk is of very limited value. Anaesthesia is very safe indeed!

REFERENCES

1. Nunn JF. Evolution of atmospheric oxygen. *Ann R Coll Surg Engl* 1968; **43:** 200-217.
2. Sykes WS. *Essays on the First Hundred Years of Anaesthesia.* 2nd ed. Edinburgh: Livingstone, 1961: 32.
3. Beecher HK, Todd DP. A study of the deaths associated with anesthesia and surgery based on a study of 599 548 anesthetics in ten institutions 1948 - 1952, inclusive. *Ann Surg* 1954; **140;** 2-35.
4. Edwards G, Morton HJV, Pask EA. Deaths associated with anaesthesia: report on 1 000 cases. *Anaesthesia* 1956; **11:** 194-220.
5. Dripps RD, Lamont A, Eckenhoff JE. The role of anesthesia in surgical mortality. *JAMA* 1961; **178:** 261-266.
6. Clifton BS, Hotten WIT. Deaths associated with anaesthesia. *Br J Anaesth* 1963; **35:** 250-259.
7. Scurr CF. Evolution and revolution in anaesthetic training. *Ann R Coll Surg Engl* 1971; **48:** 274-292.
8. Utting JE, Gray TC, Shelley FC. Human misadventure in anaesthesia. *Can Anaesth Soc J* 1979; **6:** 472-478.
9. Cooper JB, Newbower RS, Long CD, McPeek B. Preventable anesthesia mishaps: a study of human factors. *Anesthesiology* 1978; **49:** 399-406.
10. Lee JA. The anaesthetist in the operating theatre. *Anaesthesia* 1982; **37:** 1130.
11. Foster PA, Roelofse JA. *The Anaesthetist's Handbook.* 3rd ed. London: Medishield, 1982: 6.
12. Shipton EA, Roelofse JA, Van der Merwe CA. Accidental severe hypercapnia during anaesthesia. *S Afr Med J* 1983; **64:** 755-756.
13. Hogg CE. Pin-indexing failures. *Anesthesiology* 1973; **38:** 85-87.
14. Boba A. *Essays on Future Trends in Anaesthesia.* 1st ed. Berlin: Springer-Verlag, 1972: 20.