PRACTICAL POLICY FOR NON-EXPLOSIVE ANAESTHESIA*

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IN THEIR CONSTANT STRUGGLE to reduce morbidity and mortality, anaesthesiologists have tended to overlook the ever-present hazards of fire and explosion. This undoubtedly stems from the low reported incidence of explosion (1:100,000[1]), which contributes to a tendency among practitioners to consider it a negligible risk. There are other factors. Among them is the "it can't happen here" syndrome. Another is the continued desire among anaesthetists to use and teach the traditional (and familiar) techniques involving ether, cyclopropane, vinyl ether, ethyl chloride, and ethylene. Pervading all these is the problem of enforcing the necessary safety regulations affecting one's colleagues as well as the nurses, doctors, and hospital engineers.

As a result, a few of the more simple requirements are stringently met while a general laissez-faire attitude prevails. The purpose of this paper is to explain how the practical problems associated with the introduction of non-explosive anaesthesia can be solved.

Although many precautions have always been taken at the Hospital for Sick Children to prevent a fire or explosion in the operating room, no over-all plan for explosion safety existed until July 1960, when a Fire and Explosion Hazards Committee was appointed by, and made responsible to, the Hospital Director. This committee was under the chairmanship of the chief of anaesthesia, and included representatives from surgery, nursing, engineering, and administration. Its terms of reference were to study, formulate, unify, and control all measures that would minimize the hazard of explosion in the operating rooms.[2]

The committee met monthly over the next three and one-half years. It concentrated its attention on two key areas: (*a*) equipment and supplies, and (*b*) technique and procedures. Among the supplies and equipment introduced were: satisfactory bootees (after 15 types had been tested); numerous conveniently located conductive meters; improved conductive flooring and wall meters; fully conductive anaesthetic apparatus and drag chains on all operating room equipment. Included in the regulations for safe technique and procedure were: adequate instruction to all personnel, covering satisfactory clothing and measures for personal conductivity; daily checks on humidity; grounding and labelling of explosion-proof (safe) equipment; plus regular engineering checks on all operating rooms and instructions on the posting of notices regarding entry when an anaesthetic is in use. In addition, great emphasis was placed on the value and use of non-explosive anaesthetics.

Despite constant major effort to maintain all the proper precautions, it was

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always possible that with 22 operating rooms in use, occasional flaws or imperfections in technique might occur. Perhaps it was inevitable. In any event, an explosion and fire did occur during an anaesthetic in May 1964. It resulted in injury to three individuals, fortunately without fatality. A thorough investigation into the accident suggested a static spark, originating in the machine, may have been the cause—augmented, perhaps, by other factors within the room itself. The futility of hoping to avoid explosions while continuing to use explosive anaesthetic agents had been dramatically demonstrated.

The result was an immediate ban on the use of explosive anaesthetic agents in the hospital—with one exception. The exception was the tonsil suite, where four to five thousand operations had been performed annually since 1947 without operative mortality of any kind. In this area, a trial comparison of explosive and non-explosive techniques was implemented. When no demonstrable change in morbidity could be detected after six months, non-explosive anaesthesia was established in all areas. Halothane, methoxyflurane, nitrous oxide, trichlorethylene, and relaxants were then used for all anaesthesia.

Evolution of Practical Policy

A blanket rule banning the use of any drug, even an explosive anaesthetic, is unwise. Medical reasons (such as asthma) might indicate the use of ether as an anaesthetic; cyclopropane may be preferred for a patient in shock. Personnel may be inexperienced in the use of non-explosive agents and unfamiliar with their special properties. In such circumstances, the chief of anaesthesia must be prepared to train and certify such individuals for the use of these agents. Practical problems, such as lack of adequate monitoring equipment or calibrated vaporizers essential for the medically safe use of certain non-explosive agents, also make it unwise to ban explosive anaesthetics completely. For these reasons, the Fire and Explosion Hazards Committee proceeded to develop workable modifications to the general ban.

The first step was to determine what precautions against explosions were humanly possible within the limits of economic feasibility. The techniques and procedures which the committee decided upon are outlined in Chart 1. The basic

CHART 1

ANAESTHESIA SAFETY MEASURES

A *Physical Measures*

1 Two operating rooms (one in surgery and the other in E.N.T.) are designated as the only locations where explosive anaesthetic agents may be administered in the hospital.

2 Construction of these rooms must meet safe standards of conductivity and they must be fully equipped with humidity gauge, conductivity meters, etc. Each piece of equipment to be used in either room is checked initially for conductivity and is marked with yellow tape if it is satisfactory.

3 A member of the hospital engineering department makes a conductivity check daily (except Sunday) on floors in the O.R. corridor, the utility rooms, and the O.R. itself, plus the O.R. table and all other equipment in the room. The list includes as a minimum the anaesthetic table, anaesthetic cabinet, mask, tubing, stools, foot stools, pails, basin stands, hampers, and intravenous pole. He records findings on a check list and initials it.

4 Any equipment or supplies found to be non-conductive for any reason are removed from the room (and any yellow tape is removed from equipment found to be non-conductive). A verbal report is made to the operating room supervisor in these circumstances.

5 The daily log is kept in the top drawer of the anaesthetic cabinet at all times.

6 Conductive meters are maintained at the door to each operating room and staff members are instructed in safe technique as well as the means to maintain personal conductivity when the need arises.

7 Two signs reading WARNING—FLAMMABLE GAS IN USE are maintained in the drawer of the anaesthetic cabinet ready for posting inside and outside the room when an explosive anaesthetic is introduced.

B *Procedure for Using Flammable Agent*

1 Both the surgeon and the anaesthetist must agree on the need to use an explosive anaesthetic in a particular case.

2 Any additional equipment to be brought into the operating room (such as the patient's bed) must have a drag chain attached, and its conductivity checked.

3 A seven-point check list (Chart 2), certifying that all known requirements for the safe use of an explosive anaesthetic agent have been met, must be signed by the surgeon, the anaesthetist, and the circulating nurse. The anaesthetist is then responsible for posting the warning signs and may bring in the flammable agent.

4 At the end of the operation the signed check list is delivered to the office of the Chief of Anaesthesia.

decision was to designate two operating theatres, one in general surgery, the other in E.N.T. as the only two locations where explosive anaesthetics could be administered in the hospital. (In a life-threatening situation this rule can be waived, but this need has not arisen in the two and one-half years since the new policy was put into effect.) It was felt that two rooms could be kept under constant surveillance and in safe condition in a way that 22 rooms could not.

Secondary decisions outlining policies in the matter fall conveniently under two headings: (*a*) those which specify procedures for the maintenance of two operating theatres in safe condition, and (*b*) those which enumerate the procedures for the actual introduction of an explosive anaesthetic in a specific case.

Core of the technique for maintaining two rooms in safe condition is a daily check by a hospital engineer who records his findings on a checklist register that is kept in each of the two operating rooms. Everything in the room is checked for conductivity. Any damaged or non-conductive equipment is removed or replaced. The entire procedure takes an average of one hour per day, and is usually done by the night staff. In addition to making a special notation on the form whenever any item on the checklist fails to meet a safe conductivity level, the engineer informs the operating room supervisor verbally of his findings.

Before an explosive anaesthetic may be used in the hospital, both the surgeon and the anaesthetist must agree that its use is medically indicated. And before it may be introduced into either of the designated operating rooms, a special form (Chart 2) must be completed and signed by the surgeon, the anaesthetist, and the circulating nurse. This seven-point checklist, which is self-explanatory, certifies that all known requirements for the safe use of an explosive anaesthetic have been met.

The procedure outlined here does not ban the use of explosive anaesthetics

CHART 2

O.R.———

BEFORE EXPLOSIVE ANAESTHETIC AGENTS ARE TO BE USED THE FOLLOWING ITEMS MUST BE INITIALED AND THE LIST SIGNED

Upon completion of the operation, this sheet must be returned to the Department of Anaesthesia, Room 233.

1 All electrical equipment in the room has been checked and is explosion proof. ———
2 The humidity in the room has been checked and exceeds 50%. ———
3 Floor and furniture on check list in utility room have been tested and ruled satisfactorily conductive. ———
4 Conductive footwear is being worn by all personnel and has been tested on each person. ———
5 Only personnel with clothing conforming to the C.S.A. regulations will be admitted. ———
6 Ventilation equipment is functioning (pilot light is on). ———
7 The sign EXPLOSIVE GAS IN USE has been posted. ———

Signatures
Surgeon ——————
Anaesthetist ——————
Nurse ——————

Date ——————

generally or forbid it in any particular case. It merely provides a strong indication of the legal and moral responsibility attendant upon those who use flammable agents. The result has been a decline in the use of flammable anaesthetic materials at the Hospital for Sick Children to almost the vanishing point since the introduction of the programme nearly three years ago. The average is now about eight to ten per year (Chart 3). There has been no discernible change in either operative morbidity or mortality in the same period.

CHART 3
ANAESTHETICS RECORD

The following is a report on general anaesthetics administered at the Hospital for Sick Children, Toronto.

	Number of anaesthetics	Explosive anaesthetics
1956	12,860	12,694
1966	17,564	4*

*Flammable agents were used in a total of 19 cases from January 1965 to August 1967. The figures are: 1965 (7); 1966 (4); and 1967 to August (8).

It need hardly be said that both the Medical Advisory Committee and the Board of Trustees ratified the committee's programme. Subsequently, the Toronto Fire Marshal and the Ontario Hospital Services Commission accepted the principle of designating only two rooms for the safe use of explosive anaesthetics at the Hospital for Sick Children. Among other things, this has meant that additional operating rooms could be completed without the expensive special construction and other precautions to reduce explosive hazards.

Conclusion

Every anaesthetist knows that the use of any flammable anaesthetic agent involves the risk of fire or explosion. There is sometimes a danger that this risk may be underestimated because mishaps are so rarely reported, with the result that the risk is mistakenly regarded as negligible.

Some doctors, both surgeons and anaesthetists, may nevertheless believe that for certain patients the medical risk in the use of an anaesthetic can be reduced through selection of one of the explosive agents that have served them well for so long. It is their patient and they have the final responsibility. We believe they must have the opportunity to balance the risks and choose the alternative they believe will provide the least risk. On the other hand, with modern anaesthetic training, better monitoring of patients under anaesthesia, and better equipment, and in view of the wider range of non-explosive agents now available, the routine use of flammable agents is no longer either justified or advisable. Few events could be more disastrous than a lethal explosion in a healthy child undergoing routine surgery.

REFERENCES

1. Wylie, W. D. & Churchill-Davidson, H. C. A Practice of Anaesthesia. 2nd ed., Chicago: Year Book Medical Publishers (1966), p. 440.
2. Standard reference materials used by the Committee included: Canadian Standards Association, Code for Use of Flammable Anaesthetics (Safe Practice for Operating Rooms), Bulletin Z32, Ottawa, 1963; and P. J. Sereda, Safety from Fire and Explosions in Hospital Operating Rooms, Canadian Building Digest, August, 1962 (CBD-32), National Research Council, Ottawa.