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## DEATHS IN THE OPERATING ROOM

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In the ten years from 1933 to 1942 inclusive, fifty-one patients have died in the operating rooms of the Wisconsin General Hospital. During this time the Department of Anesthesia has anesthetized 44,891 patients, and has kept accurate records of each administration and of the postoperative course of the case. This series does not, however, include cases anesthetized by the surgeons for minor surgical procedures, nor those cases in which anesthesia has been induced by other members of the staff for diagnostic or therapeutic purposes. Several deaths have occurred, for instance, after the topical application of a drug to the pharynx or urethra. Since no member of the Department of Anesthesia was present no records of these exist. The purpose of this paper is to analyze the details of the deaths occurring during the administration by anesthetists, and from this point of view, in order to see what lessons may be learned from them.

It is the function of this hospital to act as a center for surgical consultation for the State. Only rarely are emergency operations performed. On the other hand, a large number of major abdominal, thoracic, or cerebral interventions are undertaken in persons debilitated by chronic diseases and old age. If it is felt that, whatever the risk, operation provides the only hope of recovery we do not hesitate to undertake it. The personnel of the Departments of Surgery and Anesthesia includes men of mature experience and judgment as well as younger residents and interns under instruction and students in their clinical years. An effort is made to ensure that patients are treated by persons of a skill appropriate to the technical difficulties of their case.

In some localities the law makes a death on the table the subject of a coroner's inquest. In times past there have therefore been occasional

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on which, when the patient appeared to be in a state of circulatory collapse, the operation has been completed in haste and the patient has been removed from the operating room before all signs of life were extinct. Not always did this artifice succeed in its object. It seems plain that a patient in such dire straits should be kept quiet and free from any superfluous trauma, while the recognized measures for the support of a failing circulation are applied. This has been our invariable rule: indeed a number of the patients to be discussed have died in the operating room some hours after the completion of the operation. The series therefore includes all the patients who, after operation, did not at least recover either consciousness or the condition in which they were before operation. This definition is necessary because some were in coma, before operation, from circulatory depression, infection, or an increase in intracranial pressure.

In table 1 are condensed the salient facts of these fifty-one cases. In two of them no anesthesia was necessary (Cases 46 and 49), the patients being already unconscious, and a member of the Department of Anesthesia merely administered oxygen, supervised supportive treatment and maintained a clear airway by intubation of the trachea in order to remove secretions. In Case 9 the death occurred during the removal of a cerebral tumor from a patient already in coma; local infiltration was performed by the surgeon. In Case 12 cocaine had been instilled into the urethra by the technician to the Urological Service and the patient died of a cocaine reaction. We do not propose further to discuss these four cases because the patients were not under the care of our department.

When a patient dies during an operation several factors must be carefully considered in assigning the cause of death. These are: the condition of the patient, the nature of the operation and the skill with which it was performed, the agent and technic of anesthesia, the wisdom and skill with which they were used, and the degree of clinical acumen displayed by surgeon and anesthetist in treating the condition when it was recognized that an emergency had arisen. In the majority of cases a combination of these factors has been responsible for the fatal outcome, and it is impossible to assign the responsibility exactly. In a few cases in this series we feel that death was mainly due to one cause. In the interests of brevity these cases will be considered first.

### 1. SURGICAL DEATHS

In eight cases (Nos. 4, 27, 28, 29, 32, 38, 43, and 49) death was due to the operation alone, and in our opinion anesthesia played no part in it. Seven were due to massive hemorrhage; one took place at a second operation (suprapubic cystostomy) in a patient already in coma after the bladder had been ruptured during endoscopic resection of the prostate. As anesthetists we feel that we are not entitled to an opinion as to

whether or not these deaths could have been avoided, and we do not propose to discuss these cases further.

## 2. DEATHS DUE TO THE PATIENT'S CONDITION

In our opinion death during operation was due solely to the condition of the patient in Cases 7 and 45.

*Case 7.*—An otherwise healthy youth of 19 was moribund from an increase in intracranial pressure caused by a cerebellar abscess. He was in coma from which he would occasionally rouse to fits of violent excitement. Respiration was depressed and irregular, and no preliminary medication had been given. Induction with cyclopropane and intubation with a cuffed tube were uneventful. Respiration failed some minutes later when the patient was placed in the prone position. The color was poor at that time but a pulse could still be felt. An incision was rapidly made and ventricular puncture performed, but circulation failed as the incision was made. Autopsy showed a large circumscribed abscess of the left cerebellar hemisphere. There was no "pressure collar" in the vicinity of the fourth ventricle.

*Case 15.*—A healthy man of 38 had suffered for years from a chronic gastric ulcer. It had long since been agreed that exploration and probably partial gastrectomy were desirable. The patient, however, was not anxious to undergo an operation. Two months before his admission he suddenly had an attack of pain in the right iliac fossa. A diagnosis of appendicitis was made and the symptoms subsided on conservative treatment. When eventually exploration was undertaken he seemed in excellent physical condition, save for some hypertension (blood pressure 168 mm. systolic and 102 mm. diastolic). Induction was with cyclopropane and maintenance with ether, both being administered by the "absorption in circuit" technic, a tracheal tube being in place. Deep anesthesia (third plane of third stage) was maintained throughout an operation which lasted for three hours. It was noticed that the pupils appeared more dilated than seemed consistent with the plane of anesthesia and the preliminary medication (morphine, grain  $\frac{1}{6}$ , scopolamine, grain  $\frac{1}{150}$ ). A retroperitoneal appendix was found and removed with some difficulty. Partial gastrectomy was then performed with even greater difficulty since an ulcer on the posterior aspect of the stomach had become firmly fixed to the pancreas. His condition after operation was excellent for 42 hours. Then he was suddenly found to be cold and sweating, his blood pressure could not be obtained and his pulse was rapid and thready. The abdomen was not unduly tender or rigid. Although his color was good, a transfusion of whole blood was given and oxygen therapy was instituted. A divergence of opinion as to the diagnosis prevailed among those in charge of the case. Some felt that his condition was due to hemorrhage; others that it was the result of a peripheral circulatory collapse. Fifty hours after the original operation, the former opinion prevailed and it was decided to reopen the abdomen and search for the source of hemorrhage.

The condition of the patient had altered but little in the previous eight hours. He received no specific preliminary medication, but had had some morphine in the course of the day. When placed on the operating table signs of pulmonary edema were present and his color was bad. Because of a delirious response to painful stimuli as the result of being moved to the operating table, a hurried

induction was performed with a mixture of nitrous oxide and cyclopropane and resulted in almost instantaneous death, respiration failing one minute before circulation. At necropsy two large myocardial infarcts were found. One was recent and the other older. It seemed as though the older one might well have been the cause of what at the time was diagnosed as appendicitis. There was also edema of the lungs and an infarct in the right kidney. Although this case is of great clinical interest, it is sufficient to submit here that death was imminent even had the patient not been anesthetized.

TABLE 1

No.	Patient	Age years	Cause*	Operation	Physi- cal status	Anesthesia	Determining complications
1	L. H.	49	4	Mastectomy	3	N <sub>2</sub> O	Hypoxia
2	E. C.	8/12	3	Bronchoscopy; bean at bifurcation	6	Ether	Hypoxia
3	L. N.	12	3	Occipital exploration	3	C <sub>2</sub> H <sub>6</sub> -Ether	Circulatory depression
4	E. R.	38	1	Cervical laminectomy	3	C <sub>2</sub> H <sub>6</sub>	Hemorrhage
5	G. S.	53	4	Dental extraction (not done)	3	C <sub>2</sub> H <sub>6</sub>	Sudden overdose
6	L. F.	46	4	Rhinoplasty (not done)	3	C <sub>2</sub> H <sub>6</sub>	? Fibrillation
7	F. G.	19	2	Drainage of cerebellar abscess (not done)	7	C <sub>2</sub> H <sub>6</sub>	Central failure
8	R. B.	13	3	Removal of cerebellar tumor	4	C <sub>2</sub> H <sub>6</sub>	Hemorrhage
9	H. P.	3	3	Cerebral decompression for subdural hemorrhage	7	Procaine	Central circulatory depression
10	A. H.	50	4	Excision of lip (cautery)	3	Pentothal-N <sub>2</sub> O	Hypoxia
11	J. A.	62	7	Gastric exploration	7	N <sub>2</sub> O-Ether-Procaine	Cardiac failure
12	H. T.	60	4	None (cystoscopy)	2	Cocaine	Cocaine reaction
13	J. C.	36	6	Suture of perforated duodenal ulcer	6	C <sub>2</sub> H <sub>6</sub>	Cardiac failure
14	J. R.	8/12	3	Repair of meningocele	6	Ether	Circulatory failure
15	R. B.	16	4	Lobectomy, second stage	3	C <sub>2</sub> H <sub>6</sub>	Hypoxia
16	S. F.	48	4	Attempted esophageal dilatation	2	C <sub>2</sub> H <sub>6</sub>	Fibrillation
17	P. G.	22	6	Attempted thyroidectomy, tracheotomy	7	C <sub>2</sub> H <sub>6</sub>	Obstruction
18	E. W.	44	4	Dilatation and curettage	2	C <sub>2</sub> H <sub>6</sub>	Overdose
19	A. H.	78	7	Transurethral prostatectomy	7	Procaine (spinal)	Circulatory failure (pulmonary thrombosis)
20	A. M.	42	7	Laminectomy (tumor)	3	N <sub>2</sub> O-Ether	Relative overdose (obstruction)
21	R. H.	24	3	Removal of cerebral tumor	3	C <sub>2</sub> H <sub>6</sub> -Ether	Trauma, hemorrhage
22	M. D.	66	3	Nephrectomy for hypernephroma	3	C <sub>2</sub> H <sub>6</sub>	Pulmonary embolism
23	S. P.	26	6	Repair of vaginal walls	2	C <sub>2</sub> H <sub>6</sub>	Cardiac failure
24	E. H.	21	7	Pneumonectomy	3	N <sub>2</sub> O-Ether	Hypoxia
25	N. B.	34	7	Thoracotomy, closure of bronchopleural fistula	4	C <sub>2</sub> H <sub>6</sub>	Hemorrhage into sound lung.
26	C. S.	68	4	Diagnostic spinal	3	Procaine (spinal)	Circulatory failure
27	E. G.	46	1	Pneumonectomy	3	C <sub>2</sub> H <sub>6</sub>	Hemorrhage
28	E. A.	54	1	Removal meningioma	2	Avertin-N <sub>2</sub> O	Hemorrhage
29	R. C.	49	1	Pneumonectomy; vena cava cut	2	C <sub>2</sub> H <sub>6</sub>	Hemorrhage

TABLE 1 (Continued)

No.	Patient	Age years	Cause <sup>a</sup>	Operation	Physi- cal status	Anesthesia	Determining complications
30	N. M.	5	4	Attempted pneumonectomy —inoperable	3	C <sub>2</sub> H <sub>6</sub> -N <sub>2</sub> O	Obstruction
31	L. L.	74	6	Endoscopic resection of prostate	5	Pentothal	Circulatory failure
32	L. T.	71	1	Thyroidectomy. Inferior thyroid artery cut	3	Procaine (Cerv. block)	Hemorrhage
33	M. B.	35	5	Open reduction of fractured femur	1	C <sub>2</sub> H <sub>6</sub>	Circulatory failure
34	S. A.	5/12	3	Suboccipital exploration (hydrocephalus)	4	Ether	Central respiratory failure
35	C. L.	54	4	Pneumonectomy	3	C <sub>2</sub> H <sub>6</sub>	Circulatory failure
36	R. M.	5/12	3	Drainage of cerebral abscess	3	Ether	Central respiratory failure
37	G. H.	2/12	3	Cerebellar exploration	2	CHCl <sub>3</sub> -N <sub>2</sub> O	Hemorrhage
38	T. C.	59	1	Cerebellar exploration	2	Avertin Procaine	Hemorrhage
39	A. D.	73	6	Cholecystojejunostomy	4	C <sub>2</sub> H <sub>6</sub> -Ether	Circulatory failure
40	W. G.	26	6	Thyroidectomy	3	N <sub>2</sub> O-C <sub>2</sub> H <sub>6</sub>	Circulatory failure
41	E. S.	64	4	Drainage pulmonary abscess	3	Pentothal- N <sub>2</sub> O	Obstruction by cuff
42	S. B.	73	6	Endoscopic resection of prostate	3	Procaine (spinal)	Circulatory failure
43	O. L.	67	1	Esophagectomy; perforation of atrium of heart	3	C <sub>2</sub> H <sub>6</sub>	Hemorrhage
44	A. P.	63	6	For repair of vaginal walls. Died after preliminary medication	3	Nil	Obstruction
45	E. C.	38	2	Exploration of abdomen	7	C <sub>2</sub> H <sub>6</sub> -N <sub>2</sub> O	Myocardial infarction
46	J. S.	8	3	Removal of cerebellar tumor	4	Nil	Central failure
47	E. C.	48	7	Gastrectomy	3	N <sub>2</sub> O-Ether	Relative overdose
48	L. N.	29	6	Colostomy	3	N <sub>2</sub> O-Ether	Relative overdose
49	M. B.	74	1	Suprapubic cystostomy after ruptured bladder	7	Nil	Circulatory failure
50	A. K.	50	6	Dilatation and curettage	4	C <sub>2</sub> H <sub>6</sub>	Coronary occlusion
51	C. O.	41	4	Thoracoplasty	3	Pentothal Nuper- caine (spinal)	Circulatory failure

<sup>a</sup> Cause: 1—Death due to operation.

2—Death due to patient's condition

3—Death due to patient's condition and operation.

4—Death due to anesthesia.

5—Death due to anesthesia and operation.

6—Death due to anesthesia and the patient's condition.

7—Death due to anesthesia, the patient's condition and operation.

### 3. DEATHS DUE TO THE EFFECTS OF THE PATIENT'S CONDITION AND THE OPERATION

In our opinion nine deaths during operation were due to these causes and anesthesia was not responsible. For the sake of brevity, the facts are shown in table 2, and the cases will not be further discussed.

TABLE 2  
DEATHS DUE TO THE PATIENT'S CONDITION AND THE OPERATION

No.	Sex	Age	Operation	Physical status	Anesthesia	Remarks
2	F	8 mo.	Bronchoscopy; attempt to remove bean at bifurcation	6	Open ether	Foreign body became impacted at bifurcation and complete obstruction resulted; left lung atelectatic before operation
3	M	12 yrs.	Occipital exploration for cerebellar tumor	3	C <sub>2</sub> H <sub>6</sub> -Ether-N <sub>2</sub> O. Closed Endotr., abs.	Death from circulatory failure following hemorrhage and trauma
8	M	13 yrs.	Third attempt to remove cerebellar tumor; marked increase in intracranial pressure	4	C <sub>2</sub> H <sub>6</sub> . Closed Endotr., abs.	Uncontrollable hemorrhage; Circulatory failure
14	F	8 mo.	Removal of cervical meningocele	3	Ether	Died suddenly when dressings were being applied
21	M	24 yrs.	Removal of tumor at base of brain	3	C <sub>2</sub> H <sub>6</sub> -Ether. Closed Endotr., abs.	Severe hemorrhage; circulatory failure
22	F	66 yrs.	Nephrectomy for hypernephroma	3	C <sub>2</sub> H <sub>6</sub>	Pulmonary emboli when renal vein was divided; immediate respiratory failure
34	F	5 mo.	Exploration for tumor of fourth ventricle	4	Ether. Endotr.	Central respiratory failure while dressings being applied
36	M	5 mo.	Drainage of multiple abscesses of brain	3	Ether	Central respiratory failure at end of operation
37	M	2 mo.	Suboccipital exploration	3	N <sub>2</sub> O-CHCl <sub>3</sub>	Central respiratory failure

#### 4. DEATHS DUE TO ANESTHESIA

In a further twelve cases (Nos. 1, 5, 6, 10, 15, 16, 18, 26, 30, 35, 41 and 51) anesthesia was the cause of death. Although most of the patients were classified as having a physical state of 3 (1) by reason of the disease from which they suffered, there was no reason to anticipate a fatal accident in any of these cases.

Two of the deaths (Nos. 1 and 10) were caused by hypoxia during anesthesia with nitrous oxide. In one case radical mastectomy was to be performed for carcinoma in a bronchitic woman of 49 who weighed 168 pounds. In the other, excision of a carcinoma of the lip was performed in a man of 50 who had some arteriosclerosis and old rheumatic carditis. He received basal narcosis with pentothal and an endotracheal tube was passed. Death occurred when the dressings were being applied. Both patients were anesthetized by anesthetists of comparatively little experience. There seems little doubt that both accidents could have been avoided by a person of greater experience.

Two deaths were due to the injudicious exhibition of spinal analgesia.

*Case 26.*—A patient of 68, with advanced arteriosclerosis and impending gangrene of the feet, died when given spinal analgesia for a diagnostic investigation of changes in temperature of the skin. He also had chronic bronchitis, and was recorded as having a "functional capacity" of III according to the definitions of the American Heart Association. The analgesic consisted of 150 mg. of procaine dissolved in 2 cm. of spinal fluid and injected moderately fast into the third lumbar interspace, with the patient in the lateral position. The patient was turned into the supine position and analgesia was found to be at the level of the tenth dorsal segment. It ascended to the seventh dorsal when the table had been placed in slight Trendelenburg position for a minute, and the table was again leveled. Five minutes had elapsed since the injection when, just as the temperature of the skin was being recorded, the patient complained of "feeling bad" and became slightly restless. The pulse and blood pressure could not be obtained, the level of analgesia had apparently not altered, and since the patient was still breathing spontaneously he was given oxygen. A few moments later respiration became periodic and then ceased. Attempts at resuscitation were unsuccessful. This accident definitely resulted from poor judgment and execution on the part of the anesthetist.

*Case 51.*—A woman of 41 had advanced bilateral phthisis and a vital capacity of less than 60 per cent of normal. She had previously undergone three stages of thoracoplasty, anesthesia being uneventfully conducted with cyclopropane and nitrous oxide. On this occasion it was decided to produce high spinal analgesia with nupercaine for the fourth stage of thoracoplasty. The patient, however, declined to remain conscious and for this reason she was given .25 Gm. of pentothal intravenously in 2.5 per cent solution. Ten cubic centimeters of nupercaine in  $\frac{1}{1,500}$  solution was then injected, the patient being in the left lateral position and the table horizontal. This caused a severe fall in blood pressure, for it could not be determined thereafter, although a feeble pulse was counted at a rate of 100. When the uppermost towel-clip was applied to the skin, the patient moved. The junior anesthetist in charge interpreted this as meaning that analgesia was not sufficiently high, and he therefore raised the head of the table ten degrees. Within five minutes pulse and spontaneous respiration ceased simultaneously, and the usual resuscitative measures were of no avail. In all, .4 Gm. of pentothal had been given. This death was due to the misuse of a method unsuitable to the condition of the patient by an anesthetist of insufficient experience. The blame rests with the senior men instructing him, for allowing him to attempt such a method in such a patient.

One patient died as the result of an accident in the course of endotracheal anesthesia using an inflatable cuff.

*Case 11.*—A man of 64 suffered from an abscess of the left lung. It had been drained once before and he now had a bronchocutaneous fistula. He showed slight secondary anemia (hemoglobin 12.1 Gm., erythrocytes 4,030,000) marked leukocytosis (55,000 cu. mm.) and generalized arteriosclerosis. Since the actual cauterization was to be used, induction was by means of 1 Gm. of pentothal in 5 per cent solution. An orotracheal tube, carrying an inflatable cuff, was passed, and anesthesia was maintained with nitrous oxide-oxygen by the to and fro absorption technic. When the patient was turned on his side respiration became somewhat shallower. As the operation began, thirty minutes after the induction of anesthesia, it was noticed that respiration was taking place entirely

through the fistulous opening. The surgeon therefore packed the opening, and thereafter no ventilation took place in spite of respiratory effort. Nor could the lung be inflated manually from the bag. The patient's color was poor, the pulse was becoming thready, and he was therefore turned into the supine position. The inflatable cuff was then deflated and as soon as this had been done again became possible to inflate the lungs manually. The circulation, however, failed within fifteen minutes. Necropsy showed "pulmonary effusion, bronchopneumonia and bronchiectasis of the left lung, and purulent bronchiectasis and atelectasis in the right lung." In this case death was probably due to respiratory obstruction caused by a bulging of the inflatable cuff over the end of the endotracheal tube (2).

Seven patients died during anesthesia with cyclopropane (Cases 6, 15, 16, 18, 30 and 35), in our opinion primarily because of anesthesia. In Cases 15 and 30, however, the technic of administration was at fault and not the agent. This may well be true of some of the earlier cases also.

*Case 15.*—A youth of 16 was to have the second stage of a left lower pulmonary lobectomy for bronchiectasis. The first stage had been uneventfully accomplished fourteen days earlier with cyclopropane anesthesia; and the patient was in comparatively good condition before the second operation. His hemoglobin was, however, but 65 per cent of normal and 4,340,000 erythrocytes per cubic millimeter were counted. Induction was performed with cyclopropane and was slow and difficult, a circumstance characteristic of reduced absorptive alveolar surface. Intubation was achieved orally with a catheter of the Haag grave type whose end was molded into a short curve and which carried two inflatable cuffs. It was passed with ease into the right bronchus past the 10½ inch mark. Severe hemorrhage was encountered ten minutes after the operation began and the blood pressure fell abruptly to 70 mm. systolic and 40 mm. diastolic. There was little respiratory exchange and the anesthetist had difficulty in "controlling" respiration. This presently led him to withdraw the endobronchial tube an inch. It was soon evident, from the improvement in respiratory exchange, that the tube had been too deeply placed so that its cuff occluded the eparterial bronchus and caused atelectasis of the right upper lobe. By that time, however, the circulatory depression had already reached a point at which it did not respond to treatment. Death was therefore due to a technical error in the use of the endobronchial technic.

*Case 30.*—A girl of 5 was to have a right pneumonectomy for congenital cystic lung and bronchiectasis. She had slight anemia (hemoglobin 70 per cent erythrocytes 4,200,000 per cubic millimeter) and the heart was displaced to the right. Partial pneumothorax had been established on the right ten days before the operation. Preliminary medication consisted of morphine grain ½<sub>12</sub> and scopolamine grain ½<sub>300</sub>, given ninety minutes before induction. Smooth, uneventful induction with cyclopropane was followed by intubation with a short semistiff tube passed by direct vision. Much pus was aspirated through the tube, and some respiratory obstruction occurred during which the pulse rate fell to 40. The left main bronchus was then intubated with a number 4 Magill tube carrying an inflatable cuff. When this was in place, however, respiration became inefficient and the patient's color poor. The tube was then withdrawn



into the trachea. For a time ventilation seemed adequate and maintenance was achieved by the semiclosed technic. When the operation began the patient coughed and expelled the tube from her larynx. A number 3 Magill tube without a cuff was then passed into the trachea. At intervals it became obstructed by pus, and it kinked sufficiently to prevent the effective use of suction. As the pleura was opened, circulation suddenly failed and did not recover when artificial ventilation was instituted. Postmortem examination confirmed the diagnosis and showed a small patch of atelectasis and very little pus in the left lung.

This death was due to the effect of the recurrent bouts of hypoxia during anesthesia. The attempt at bronchial intubation was probably ill-advised or poorly executed in this case. It is often difficult to remove viscid secretions adequately through the small tubes appropriate in children. An experienced anesthesiologist conducted the case, and it is doubtful whether the death could have been avoided.

Five patients died in a manner suggestive of abrupt cardiac failure during anesthesia with cyclopropane.

*Case 18.*—A woman of 44 was to undergo the completion of an inevitable abortion. She had 62 per cent hemoglobin and 4,600,000 erythrocytes per cubic millimeter and her blood pressure was normal. Some physical signs suggestive of early phthisis were found in the left upper lobe and she showed slight enlargement of the thyroid gland. Anesthesia by the to and fro absorption technic was conducted by a student under the constant supervision of a senior resident and induction was begun with flows of 5 liters of oxygen and 320 cc. of cyclopropane per minute. When the bag had filled with oxygen the flow was reduced to 300 cc. per minute. Induction was very slow: five minutes elapsed before the third stage was entered. The evidence of a bystander, proffered later, suggested that the color was poor at this time, but the signs were those of the upper half of the first plane. The flow of oxygen was increased to 400 cc. per minute, and the cyclopropane was left running at 320 cc. per minute. Ten minutes after anesthesia was begun, and just as the operation was starting, the blood pressure was normal, the pulse rate was 60 and the respiratory rate was 28. The eye balls were still moving and the flow of cyclopropane was stopped. Two minutes later respiratory movement suddenly ceased as the cervix was being dilated. The pulse vanished at the same time. Treatment was of no avail. This was a clear case of primary cardiac failure. It seems almost incredible that a relative overdose of the agent could have been administered, but it is possible that some technical error was committed.

*Case 16.*—Cyclopropane anesthesia was administered to a woman of 48 for dilatation of an esophageal stricture. She suffered from postmenopausal psychosis and had attempted to commit suicide by swallowing lye. She had successfully undergone the same treatment for the stricture in each of the previous three weeks; the preliminary medication, agent, technic, and personnel being identical on each occasion. Apart from her mental condition and some secondary anemia (hemoglobin 65 per cent; erythrocytes 3,733,000 per cubic millimeter) she seemed a normal subject. Induction was begun with an excess of oxygen and a flow of 500 cc. per minute of cyclopropane. After one minute the flow of oxygen was reduced to 300 cc. per minute. In three minutes the third stage was entered, and after seven minutes, when the patient showed signs of being in the

second plane, the flow of cyclopropane was stopped. Nine minutes from the start of anesthesia the systolic pressure had risen 20 mm. from the preoperative level, the pulse rate was 84 and the patient's condition seemed good. The instruments were not as yet ready and the surgeon, seated next to him, was discussing the patient's condition with the anesthetist. Suddenly the latter felt the pulse vanish beneath his finger, and respiration ceased at the same moment. Efforts to resuscitate were of no avail. The anesthetist was a senior resident of considerable experience. This also seems a clear case of primary cardiac failure.

*Case 35.*—Pneumonectomy was to be performed in a man of 54 for carcinoma of the right upper lobe. The patient was in good general condition, although he had lost fifty-one pounds in four months. He showed slight secondary anemia (hemoglobin 10.8 Gm. per cent; erythrocytes 3,650,000 per cubic millimeter) and was coughing up some mucoid sputum. Induction with cyclopropane-oxygen was uneventful, the only evidence of the second stage being some talking by the patient. After four minutes of anesthesia the blood pressure had risen from 120 mm. to 180 mm. systolic and from 80 mm. to 90 mm. diastolic. The patient appeared to be in the second plane of the third stage, and was exhibiting mild signs of pharyngeal obstruction. The ampoule of cyclopropane had run out at this point. A pharyngeal airway was then inserted, the mandible being fully relaxed. As the anesthetist replaced the mask on the face and refilled the bubble with oxygen he noticed that pulse and respiration were both absent. All efforts to resuscitate proved vain. At autopsy the heart was found moderately hypertrophied, there was congestion of the liver and spleen, and evidence was found of disseminated sporotrichosis.

*Case 5.*—An extremely fat woman of 55 was to have all her remaining teeth extracted. She had a history of rheumatic carditis and suffered from hypertension, arteriosclerosis and enlargement of the heart. The thyroid gland was also enlarged, but there were no signs of toxicity; and there was marked pulmonary emphysema. She weighed 203 pounds and measured five feet one inch. Eight days earlier she had been successfully anesthetized with ethylene and nitrous oxide, after preliminary medication with morphine, grain  $\frac{1}{4}$ , and scopolamine, grain  $\frac{1}{100}$ , for dilatation and curettage. At that time her blood pressure had been 150 mm. systolic and 100 mm. diastolic. Immediately before induction for the second operation it was 210 mm. systolic and 100 mm. diastolic; morphine, grain  $\frac{1}{6}$  and scopolamine, grain  $\frac{1}{150}$ , had been given ninety minutes before. Induction was begun by allowing 2500 cc. per minute of oxygen and 600 cc. per minute of cyclopropane to flow into a closed system, no canister being in place. Early in induction the flow of cyclopropane was increased to 1200 cc. per minute for fifteen seconds. There was some hyperpnea because of the accumulation of carbon dioxide, and this was succeeded by respiratory depression from the agent. After one and a half minutes, respiration being almost arrested, and with the eyeballs still moving, nasotracheal intubation was performed by direct vision. The cords were seen to be well abducted. The patient did not breathe after intubation and a pulse could not be palpated. Artificial ventilation, by blowing air into the tube, was at once begun, but the color became grey. Saline and glucose solutions were administered intravenously, and coramine and adrenalin were injected into the heart. She was then placed in a mechanical respirator, oxygen being administered through the endotracheal tube, and the intravenous saline being continued. Neither circulation nor respiration was recovered. Autopsy revealed a fibrotic and arteriosclerotic heart, chronic passive

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congestion of liver, spleen, and kidneys, and atelectasis of both lower lobes. In the opinion of the pathologist the latter condition may have been present before anesthesia.

In cases 35 and 5 death was undoubtedly the result of primary cardiac failure. It is interesting to speculate as to whether the stimulus of the airway touching the pharyngeal wall in the first case, and a tube being inserted into the trachea in the second case (3) may have caused a reflex vagal inhibition of the heart.

*Case 6.*—A woman of 46 was to have a fourth plastic operation for the correction of a cicatricial deformity of the face resulting from the previous excision of a carcinoma. She had tertiary syphilis and some aortitis. The first operation was performed with local infiltration with procaine, and consisted of a partial excision of the growth. Five months later a further excision was performed with nitrous oxide-ethylene-ether. In the ensuing year she was given three uneventful narcoses with cyclopropane by the closed endotracheal absorption technique. On the last occasion she was very much afraid of anesthesia. She received morphine, grain  $\frac{1}{4}$ , and scopolamine, grain  $\frac{1}{2000}$ , at 6:30 a.m. and induction with cyclopropane was begun at 7:55 a.m. At 8:05 a.m. circulation ceased abruptly and artificial ventilation with oxygen for forty minutes had no effect. The anesthesiologist, whose experience is wide, remarked at the time that this case resembled death due to ventricular fibrillation more closely than any other he had seen. It occurred in fairly deep anesthesia. At autopsy, myocardial fibrosis and coronary sclerosis were found, and there was some scarring and thickening of the aortic intima. Both lungs showed emphysema and atelectasis.

### 5. DEATH DUE TO THE EFFECTS OF ANESTHESIA AND OPERATION

*Case 33.*—An open reduction of a fracture of the neck of the left femur was undertaken in a woman of 35. Except for the fact that she was unduly fat, her physical condition was good. Anesthesia was uneventfully induced with cyclopropane-oxygen and caused the blood pressure to rise from 160 mm. to 180 mm. systolic and from 100 mm. to 110 mm. diastolic, and the pulse rate to fall from 120 to 86. Some arrhythmia was noticed twenty-three minutes after the start of induction, and twelve minutes after the operation had begun, anesthesia being then of the second plane. Oxygen was added to the contents of the bag and the arrhythmia disappeared. Ten minutes later the pulse suddenly became impalpable and the blood pressure could not be obtained although some oscillations of the mercury were seen at about 60 mm. Spontaneous respiration, however, continued normally for eighteen minutes more. At the time of the circulatory collapse oxygen was substituted for the anesthetic mixture, and when respiration failed, the trachea was intubated and manual ventilation with oxygen was instituted. Necropsy revealed some atelectasis of the dependent portions of both lower lobes. When histologic sections of the lungs were examined, however, globules of fat were found in the vessels lining the alveoli. It was the pathologist's opinion that the quantity of fat present was, of itself, not sufficient to cause death. He thought it probable that it had nevertheless given rise to sufficient hypoxia to render the myocardium liable to a sudden failure.

### 6. DEATHS DUE TO THE COMBINED EFFECTS OF ANESTHESIA AND THE PATIENT'S CONDITION

In the interests of brevity these ten cases are shown in tabular form in table 3. Some explanatory notes are, however, necessary.

TABLE 3  
DEATHS DUE TO A COMBINATION OF ANESTHESIA AND THE PATIENT'S CONDITION  
(For operation and determining complications—see Table 1)

Case	Age	Phys. state	Preoperative complications	Anesthesia	Contribution of anesthesia to death
13	36	6	Syphilitic carditis; chronic nephritis; malignant hypertension; signs of cardiac failure 5 hrs. after perforation of duodenal ulcer	C <sub>2</sub> H <sub>6</sub>	Attempt to administer nitrous oxide ether failed because patient "would not tolerate ether." There may have been some technical ineptitude about the administration.
17	22	7	Carcinoma of thyroid—compression of trachea; almost complete respiratory obstruction	C <sub>2</sub> H <sub>6</sub>	Anesthetist unable to intubate when obstruction became complete after induction. Tracheotomy performed but too late. Tube also eventually passed too late.
23	26	2	Mild diabetic; extremely obese	C <sub>2</sub> H <sub>6</sub>	Sudden respiratory arrest. Air-oxygen used as diluent by inexperienced anesthetist. Possibly hypoxia of overdose.
31	74	4	Arteriosclerosis; incipient cardiac failure; auricular fibrillation; sarcoma clavicle	Pentothal	There may have been a relative overdose of the agent. Died during operation, twenty minutes after induction.
39	73	4	Carcinoma of head of pancreas; arteriosclerotic cardiac disease; fibrillation; incipient failure; gross debility	C <sub>2</sub> H <sub>6</sub>	Deficient relaxation. High concentration of cyclopropane given; the high concentration of ether added. Probable relative overdose in an attempt to secure relaxation.
40	26	3	Extreme hyperthyroidism from toxic adenoma, otherwise healthy	C <sub>2</sub> H <sub>6</sub>	Attempt to anesthetize with N <sub>2</sub> O for 30 minutes, then cyclopropane used. Death from abrupt circulatory failure after 1½ hrs. There may have been hypoxia in first half hour, or the cyclopropane may have caused circulatory failure.
42	73	3	Advanced arteriosclerosis; functional capacity III; asthma; pleurisy	Procaine (Spinal)	Circulatory failure 5 minutes after spinal given. Poor judgment in choice of method for this patient.
44	63	3	Arteriosclerosis, functional capacity III; diabetes mellitus; asthma	None	Given 2 doses of morphine, grain 1/16 and scopolamine, grain 1/300 one hour apart. Became irrational, acute decompensation developed and patient died.
48	29	3	Rapidly growing carcinoma of colon; previous ileo-transversostomy; now has fungation of growth and profuse secondary deposits	N <sub>2</sub> O-Ether	Induction by closed technic. Rapid addition of ether. Circulatory failure early during operation, probably due to relative overdose.
50	50	4	Gross hypertension; signs of cardiac failure; former cerebral hemorrhage	C <sub>2</sub> H <sub>6</sub>	Recent coronary occlusion found at autopsy. Probably there was a relative overdose of cyclopropane during induction.

*Case 39.*—This patient suffered from advanced carcinoma of the head of the pancreas and was grossly jaundiced. He was also in a state of impending circulatory collapse and showed auricular fibrillation. Anesthesia was attempted with cyclopropane, and at the beginning of operation relaxation of the abdomen was deficient. The gallbladder rest was raised soon after the operation began and from then on no readings of blood pressure could be obtained. Intubation was performed by the oral route, and ventilation was manually augmented through the tube, a high concentration of cyclopropane being used. The pulse was by now almost imperceptible and the abdomen was still rigid. In an effort to secure relaxation, ether was added to the cyclopropane and manual ventilation was continued. It is difficult to say exactly when circulation ceased, but the patient was probably dead seventeen minutes after the ether was added.

*Case 40.*—This young man was in excellent condition except for the extreme toxicity resulting from an adenoma of the thyroid. He had marked exophthalmos and his metabolic rate had been 172 per cent of normal a few days earlier but had fallen to 124 per cent before operation. Twenty-two minutes were expended in induction with nitrous oxide, and the operation then lasted eighty minutes. The patient had received morphine, grain  $\frac{1}{4}$ , and scopolamine, grain  $\frac{1}{300}$ , as preliminary medication, and this proved inadequate for maintenance with nitrous oxide. During induction some hypoxia was present. Cyclopropane with an excess of oxygen was used during the remainder of anesthesia, and death occurred as the operation was being completed. The patient suddenly became pale and the pulse disappeared. The blood pressure had shown the rise which is characteristic of thyroidectomies, but in the thirty minutes before death the pulse rate had slowed from 140 to 84. Three reasons may be invoked to explain this case. Patients with marked thyrotoxicosis occasionally exhibit cardiac failure during operation irrespective of the anesthetic. It may be that the hypoxia to which he was subjected during induction gave rise to damage which proved fatal; or the cyclopropane may have precipitated the cardiac failure.

*Case 41.*—The patient was a woman of 63, weighing 148 pounds, and suffering from asthma, arteriosclerosis, hypertension, and diabetes mellitus. She received two doses of morphine, grain  $\frac{1}{2}$ , and scopolamine, grain  $\frac{1}{300}$ : one, two hours and the other, one hour before operation. When brought to the operating room she was irrational and very restless and was restrained by the orderly. At this time her color and pulse were good. Twenty minutes later she suddenly became dusky, her respirations were inaudible and the pulse was faint and irregular. Artificial respiration with oxygen was of no avail. Although autopsy was not performed, it seems clear that this patient died of acute decompensation while waiting for operation. She had been treated with digitalis up to the time of operation. It is possible that a pulmonary or coronary embolus was the cause of death. The preliminary medication, however, was excessive for a patient in her condition.

#### 7. DEATHS DUE TO THE COMBINED EFFECTS OF ANESTHESIA, OPERATION AND THE CONDITION OF THE PATIENT

The details of these six cases are shown in table 4. We feel that at three factors conspired to provoke the fatal outcome in them. In Case 19 the strain of operation and anesthesia would probably have resulted fatally, irrespective of what method or technic was used. In Cases 24

TABLE 4  
DEATHS DUE TO A COMBINATION OF ANESTHESIA, THE PATIENT'S CONDITION,  
AND THE OPERATION  
(For operation and determining complications—see Table 1)

No.	Age	Physical state	Preoperative complications	Anesthesia	Remarks
11	62	7	Bleeding from gastrointestinal tract; extreme anemia; mitral stenosis; functional capacity III; hydrothorax	N <sub>2</sub> O-Ether-Procaine	Relative overdose of ether. Procaine superfluous.
19	78	7	Hypertrophy of prostate; arteriosclerosis; emphysema	Procaine (spinal)	Collapsed at end of operation. Pulmonary thrombosis and a fresh thrombus in left ventricle found at necropsy.
20	42	3	Tumor of spinal cord; spastic paralysis	N <sub>2</sub> O-Ether	Patient died towards end of operation. At one point an excessive dose of ether was given and there had been obstruction during induction.
24	21	3	Tumor of right lower bronchus; atelectasis right lower lobe	N <sub>2</sub> O-Ether	Fragment of tumor broke off, was blown into trachea and then aspirated into bronchus of sound side. Death from respiratory obstruction. Endobronchial anesthesia might have saved this patient.
25	34	4	Pulmonary abscess and bronchocutaneous fistula	C <sub>2</sub> H <sub>6</sub>	Hemorrhage into sound lung while attempting to close fistula. Intubation and drainage by suction should have saved the patient.
47	48	3	Bleeding from carcinoma of stomach; secondary anemia; arteriosclerosis	N <sub>2</sub> O-Ether	Relative overdose of ether at the close of operation. Circulatory failure.

and 25, although surgical accidents provoked the cause of death, the patients could probably have been saved had appropriate measures been instituted in time by the anesthetist.

#### DISCUSSION

One of us (4) has recently called attention to the fact that death during operation and anesthesia has occurred about once in every 1000 cases in a series of almost 250,000 cases in five teaching hospitals on three different continents. The present series of 47 deaths in 44,891 administrations means a mean immediate mortality of .104 per cent, whereas the mean mortality of the 227,546 cases quoted in that paper is .12 per cent. In that paper the attitude of an anesthetist towards death on the table is outlined. Stress is laid on the fact that the particular anesthetic agent in use is of less importance than its judicious application. We wish to reaffirm and emphasize this belief here. As a matter of interest, the incidence of deaths during the use of the various agents is shown in table 5. It will be noticed that the incidence of deaths is higher with ether than with cyclopropane, and that the figure for pento-

TABLE 5  
INCIDENCE OF DEATHS DURING OPERATION BY AGENTS

Main agent	Total deaths	Total cases anesthetized	Incidence %
N <sub>2</sub> O.....	3	4,679	0.064
CHCl <sub>3</sub> .....	1	163	.61
C <sub>2</sub> H <sub>6</sub> .....	22	22,063	.0997
Ether.....	12	9,741	.123
Procaine.....	5	4,772	.1047
Nupercaine.....	1	63	1.59
Pentothal.....	2	1,568	.1275

Total cases considered: 43,049.

Remaining 1,845 with other agents; No deaths.

Forty-six cases are considered here; one patient received no anesthetic agent.

that is almost identical to that for ether. Both the latter are higher than the mean of .104 per cent. The figures for nupercaine and chloroform are not significant since too few patients have been anesthetized with these agents to make the figures comparable. The figure for nitrous oxide deserves the note that this agent is used for almost all cerebral operations and the majority of interventions in desperately ill patients.

The decade under consideration covers the "lifetime" of cyclopropane as an anesthetic agent. It is not our purpose to discuss its safety or utility here. We merely submit that, in our hands, it has proved no more dangerous than other agents.

TABLE 6  
INCIDENCE OF DEATHS DURING OPERATION BY TECHNIC

Technic	Total deaths	Total cases anesthetized	Incidence %
Open.....	2	2,308	0.087
Insufflation.....	3	2,815	.107
Semiclosed.....	2	2,125	.094
Absorption.....	31	30,572	.101
All Inhalation.....	38	37,820	.10
Intravenous.....	2	1,577	.127
Spinal.....	4	2,878	.139
Regional and Infiltration.....	2	1,882	.106

Total cases: 44,157.

Other technics: 737; no deaths.

Table 6 shows the incidence of deaths during anesthesia according to technics. The figures support our view that the inhalation methods are less conducive to fatal accidents than others; for, with the exception of regional analgesia, the death rate is higher with intravenous and spinal methods.

It should also be mentioned that, in addition to the cases under consideration, three patients have died in the postoperative period for reasons for which the anesthetic was directly to blame. These will be discussed in a separate communication.

#### SUMMARY

Fifty-one patients have died in the operating rooms of the Wisconsin General Hospital during the decade 1933 to 1942 inclusive. During this time the Department of Anesthesia has anesthetized 44,894 patients, of whom 47 died during anesthesia. The causes of death are summarized as follows:

1. Deaths due to operation: 8 cases.
2. Deaths due to the patient's condition: 3 cases.
3. Deaths due to the patient's condition and operation: 10 cases.
4. Deaths due to anesthesia: 13 cases.
5. Death due to anesthesia and operation: 1 case.
6. Deaths due to anesthesia and the patient's condition: 10 cases.
7. Deaths due to all three factors: 6 cases.

The details of these cases are presented and discussed. The incidence of deaths during anesthesia according to agent and technic is given in tabular form.

The majority of these fatalities could have been avoided by the exercise of greater skill or judgment. We believe that these attributes will become more readily available as the number of well-trained and experienced professional anesthetists increases.

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