Problems in Neurosurgical Operations on Elderly Patients —From the Viewpoint of Anesthesiology—

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Summary

The statistical data in this paper suggest that the number of neurosurgical operations on elderly patients will further increase and halothane anesthesia will maintain its popularity until the advent of a better anesthetic agent. The specificity of elderly patients and important preoperative preparations are discussed. Pre- and postoperative complications were most frequently found in the cardiorespiratory system. PaO_2 decreased postoperatively, whereas PaCO_2 was often lower than normal. Good communication between the anesthesiologist and the neurosurgeon is fundamental for safe neuroanesthesia on problematic elderly patients.

Key words: Neurosurgery, geriatric anesthesia, anesthetic complication, respiratory physiology, statistics

Elderly patients have many problems with anesthesia. The morbidity and mortality rate in geriatric anesthesia is much higher than that of younger patients. The problems with elderly patients undergoing neurosurgical operations are briefly dealt with from the viewpoint of anesthesiology.

I. Definition of elderly

Since aging is an incessant process in living organisms, it is difficult to define when a man becomes elderly. The American Medicare System has conveniently described elderly individuals at a chronological age of 65 years or over. The Japanese Welfare System has decided to cover the medical fees of people over 70 as an old age benefit. This is convenient for the government, but as physicians, we are more concerned with the biological or physiological age of the patient.

For statistical purposes, physicians also have to decide some standard for determining the so called "elderly". Dr. Lorhan, the author of "Anesthesia for the Aged", dealt with patients of 70 years of age or over.⁹⁾ In this paper, we consider patients over the age of 60 as elderly for statistical purposes, but for the pathophysiological discussion, the biological age is also

used.

II. Number of patients undergoing surgery

Surgery on people of advanced age has greatly increased due to the progress of medicine and recent socioeconomic developments. It has been said that with the introduction of Medicare in 1966, surgeons and anesthesiologists began seeing a greater number of elderly patients undergoing surgery in the U.S.A. A similar increase in elderly patients has been observed in Japan after the establishment of a free medical care system for the aged. Nearly 20% of the operations performed in our hospital during recent years were on patients over 60 years of age. Operations on patients in their 80's and 90's were not rare for genitourinary or digestive problems, but in neurosurgery, operations on patients over 60 were remarkably few (Table I). This may be due to the fact that patients without immediate subjective suffering, obvious signs of neurological distress such as severe headaches, or life-threatening diseases in the digestive or urinary organs, as well as those whose neurological recovery was doubtful after surgery, were probably excluded from surgical treatment.

Since the morbidity rate in the neurological

Table 1 Number of elderly patients undergoing operations under general anesthesia.

	Age	60's	70's	80's	90's	Total
Neurosurg.	{ male	28 cases	7	2	0	37
	{ female	32	3	0	0	35
Other op.	{ male	365	224	24	3	616
	{ female	326	154	16	0	496
Total		751	388	42	3	1184

Among 6,266 cases from July 1, 1975–June 30, 1978.

Table 2 Pathognomonic problems found in elderly patients.

	Preoperatively existed	Postoperatively developed or aggravated
Circulatory	582 cases	318
Respiratory	379	99
Digestive	288	13
Urinary	187	13
Neurologic	80	63
Metabolic	69	22
Endocrinologic	55	11
Electrolytes	48	2

Circulatory problems include extreme hypotension and hypertension. Some patients had more than two problems; 1,184 geriatric anesthesia cases from July 1, 1975 to June 30, 1978.

field is likely to increase as the age advances as in other areas, the scarcity of elderly patients undergoing operations may be due partly to a hesitation or a general reluctance by physicians to operate on the elderly with present or potential neurological disorders.

An elderly individual of 65 has a life expectancy of more than 10 years and at 80 years of age, approximately 6 years.¹⁶⁾ As neurosurgery advances and is able to assure mental and intellectual wholesomeness and a more meaningful life after surgery, operations on the elderly will increase greatly.

III. Specificity in the preoperative laboratory data

Aging in itself reduces a person's capability to cope successfully with diseases and other stresses. Since elderly patients have a long life history, they usually have developed a wide variety of physical conditions and complications (Table 2).

Although we find elderly people who appear more energetic and vigorous than youths, their operative mortality is considerably higher than

that of the young. The old cliché "as old as his arteries" is unfortunately applied. Physicians must not be deceived by the external appearance of the elderly. The blood count data in elderly patients on operative schedules were within the normal ranges except for some cases with specific changes due to corresponding diseases. This may mean that the blood count data does not always indicate the true reserve ability of a patient. Polycythemia may be associated with emphysema. The hemoconcentration may be due to a reduced blood volume often found in fasting patients with neurological disorders.

With an advance in age, the vital capacity and forced expiratory volume decrease (Table 3). Fibrosis and emphysema are often the contributing factors and result in an increase in ventilatory dead space, residual capacity and the closing volume of peripheral airways.

These pathological changes in the lungs aggravate the uneven distribution of the ventilation perfusion ratios,¹⁵⁾ and may be attributable to the lowered arterial oxygen tensions in elderly patients (Table 4). Morioka has advocated a PaO₂ standard for the elderly

Table 3 Some laboratory data in elderly patients.

Hemoglobin					
< 8 g/dl	< 10	< 12	< 15	15 ≤	Total
12 cases	47	336	605	86	1086
Vital capacity					
< 1000 ml	< 2000	< 3000	< 5000	5000 ≤	Total
8 cases	244	531	240	1	1024
Forced vital capacity for 1 second					
< 40 %	< 60	< 70	< 80	80 ≤	Total
21 cases	51	143	326	354	895
Blood glucose					
< 60 mg/dl	< 80	< 120	< 140	140 ≤	Total
1 case	42	819	111	75	1048

Among 1,184 geriatric cases.

Table 4 Preoperative PaO₂ in elderly patients undergoing general anesthesia.

Age	No.	< 60 torr	< 70 torr	< 80 torr	< 90 torr	≥ 90 torr	Total	*Post-op low PaO ₂
60's	447 cases	4.9 %	18.3	38.1	28.2	10.5	100 %	48.5 %
70's	269 cases	4.5 %	15.2	46.9	23.4	10.0	100 %	49.1 %
80's	27 cases	3.7 %	14.8	29.6	40.8	11.0	100 %	63.6 %
90's	1 case						100 %	

* Percentages of cases in whom PaO₂ decreased more than 5 torr after the operations.

744 cases among 1,184 geriatric general anesthesia cases from July 1, 1975 to June 30, 1978.

with the following formula:

Advantageous PaO₂ for an elderly patient
 $> 100 - \text{age} \div 4$ torr.

Severe diabetes mellitus, often found in elderly people, also lowered the arterial oxygen tension probably through its angiopathic impairment of the alveoli and synthetic abnormality of a pulmonary surface active substance.¹⁴⁾

In contrast to the pulmonary ventilatory function tests, which need good communication and cooperation from the patient, blood gas analysis can be performed on an uncooperative or unconscious patient, and this is useful for patients with neurological problems. However, the blood gas determination again does not reveal the reserved activity in respiratory dynamics.

Although the mean value of PaO₂ in elderly patients decreases with an advance in age, there are some very old but seemingly healthy patients who have almost normal values of oxygen tension and other laboratory data. Their almost normal laboratory data, and the fact that they underwent an operation in spite of their advanced age, may suggest that, if they had no disease that required surgical treatment, they would have been healthier than ordinary people in their equivalent age group. In other words, a high PaO₂ might be one of the reasons for their longevity.

IV. Important preoperative preparations

Since the aging process most often appears in the cardiorespiratory system, an elderly person undergoing surgery tends to produce ar-

rhythmia, hypotension and hypertension in hemodynamics, as well as atelectasis, pneumonia and other complications in the respiratory system, as shown in Table 2. PaO_2 tends to decrease postoperatively, even in those patients who had high PaO_2 , and PaCO_2 increases. For the prevention of postoperative respiratory complications, the value of preoperative training in pursed-lip breathing and deep breathing can not be overemphasized. Patients are encouraged to refrain from smoking.

As aging proceeds, parenchymal cells decrease, and the various organs become atrophied. The brain is not an exception, and this may be one of the causes of intellectual deterioration in the elderly.⁸⁾ Senile and arteriosclerotic psychosis should be differentiated preoperatively from neurosurgical disorders lest they be misinterpreted as a result of neurosurgery or anesthetic complications.

Thus, the elderly are handicapped from many points of view. There is a trend to avoid anesthesia for the elderly as much as possible, especially when a high operative or postoperative mortality is feared.

Patients with an abnormal but stable ECG over a long period of time, without any cardiac failure, may tolerate the operation well, but patients with present cardiorespiratory failure, or within three months of myocardial infarction, have the highest mortality rate. Surgical treatment can not be completely free from potential hazards.

When operative treatment is mandatory for these patients, it is a philosophical problem for the patient and his family whether to risk life in an operation or to die without receiving surgery. We must not hesitate to provide anesthesia when emergency surgical procedures become a necessity.

Telling the true high operative risk to the patient himself is not only useless, but it can also have bad psychological effects on the preoperative morale. Instead of telling the real operative hazards to the patient, the necessity of the operation and its accompanying risks should be well explained to the immediate family and "informed consent" should be obtained.

As a person ages, the intellectual and mental acuity decreases, and the elderly appear dull and insensitive to anxiety. Elderly people often

say that they have lived long enough and are not afraid to die, but the fear of death becomes grave when it becomes a very real and immediate possibility. Even the elderly will generally become apprehensive before an operation.

In many hospitals it was routine to omit preoperative administration of narcotics, sedatives or tranquilizers to patients undergoing craniotomy for fear of misreading the cause of mental obtundation immediately after the operation, especially when the patient was elderly.

Dunsworth⁴⁾ reported that 1% of his sedated patients developed premature ventricular contractions (PVC), but among unsedated patients, 12% developed PVC's and 9% developed other arrhythmias excluding tachycardia and bradycardia. Recently, some effective antagonists, such as Naloxon®, to narcotics and their congeners,¹²⁾ and physostigmin to the diazepam derivatives²⁾ have become available. Barbiturates are being appraised for their action of protecting the brain from hypoxia.^{5,10)} Preoperative medication must be reconsidered even for elderly patients scheduled for neurosurgery.

Belladonna derivatives have been used for a long time as premedicants even in neurosurgery. They are a potent suppressor of vagotonic hyperreflexia, and decrease the airway secretion. The later action will become a cause of postoperative pulmonary complication in the elderly.¹³⁾ Since the irritable inhalation anesthetics as ether are used less frequently, the need of Belladonna derivatives have decreased. Scopolamine should be avoided in elderly patients.

Most anesthetic side effects are handled safely by the administration of proper drugs intravenously. For example, fatal accidents after subarachnoid anesthesia have markedly decreased in Japan after the preoperative establishment of an intravenous route for drug administration was approved by the Welfare System and became a routine preoperative procedure.

The subcutaneous veins of the elderly are usually large and bulge out from the skin surface. Intravenous catheterization seems very easy. However, the external appearance of the elderly, seemingly healthy before the operation, can deceive us into a false sense of security. Just before anesthesia, the veins may be

constricted or collapse due to either a sympathetic reaction to anxiety or hypovolemia. This venous constriction and the loss of elasticity of the venous wall make venipuncture more difficult, especially when the intravenous administration of drugs is urgent.

Because of the time involved and the potential difficulty, the preoperative establishment of more than one intravenous route with an indwelling plastic needle or catheter is a prerequisite for safe neuroanesthesia. Recently, many ways to approach the subclavian or jugular vein have been introduced. They may be useful for a competent neurosurgeon or anesthesiologist.¹⁾

V. Problems in anesthesia for neurosurgery on elderly patients

Anesthetic methods in the past decade have greatly changed and the use of halothane anesthesia has sharply declined to about 10% in general surgery. However, it is still used in about 60% of neurosurgical operations (Table 5).

The occurrence of a prolonged emergence from general anesthesia, such as NLA, and life-threatening hypertension under some anesthetics seem to have been feared in neurosurgery more than the rare occurrence of halothane hepatitis and this resulted in halothane being retained as the most popular anesthetic in neurosurgery.

Although ketamine is preferred by many neurosurgeons for its inherent characteristics of retaining respiration and airway reflexes, it does not guarantee an open airway in the mouth. The loss of the fat pad in the facial skin, lack of teeth and shrinkage of the alveolar ridges make it difficult for both the unconscious elderly patient and the anesthesiologist to keep a patent airway or to apply a face mask. Endotracheal intubation will often be mandatory even for a short period of anesthesia for neurological examinations such as carotid angiography.

In spite of the shrinkage of most vital organs and the whole body as manifested in a shortening of height and stature in the elderly, the internal diameter of the trachea and hence the respiratory dead space increases. A comparatively larger endotracheal tube is necessary for the elderly.

Table 5 Anesthetic methods used for operations on elderly patients.

	Neurosurg.	Other op.
N ₂ O + halothane	46 cases	76
N ₂ O + NLA	25	373
N ₂ O alone	1	0
N ₂ O + Ketalar	0	41
Other gen. anesth.	0	54
N ₂ O + Epidural b.	0	200
Epidural b.	0	251
Subarachnoid b.	0	58
Conduction b.	0	5

Hypotensive anesthesia

With nitroprusside	15	0
With trimethaphan	5	0

Various drugs manifest altered effects in elderly patients. Due to a reduction in receptor sensitivity,⁷⁾ drugs to facilitate organ functions will become ineffective, while reductions in both the clearance and physiological accommodation to bioactive substances often result in unexpectedly profound suppression with muscle relaxants and anesthetics.³⁾ An abrupt change in hemodynamics due to anesthesia is normally adjusted in a reflex manner within minutes in youths. This adjustment may be delayed in elderly patients.

A long period of absolute bedrest after a cerebral vascular accident and continued treatment with adrenocortical steroid hormones, tranquilizers, antihypertensives and stimulants make a patient more vulnerable to the increased load on the cardiovascular system and other iatrogenic stresses accompanying surgery. Deliberate hypotension or hypothermia may be beneficial in neurosurgery, but they should be applied using careful methods such as the micro-mini drip administration by Hatano⁶⁾ with elderly patients to avoid cardiovascular accidents.

Anesthesia lasting more than 10 hours is not infrequent (Table 6). An extremely large operative invasion, accompanied by profuse hemorrhaging, and an extreme rise and fall of arterial blood pressure, are not rare (Table 7).

The brain is the most important organ for a man as *HOMO SAPIENS*, and requires the most careful and minute handling during neurosurgery. Fortunately, unlike an operation on the cardiorespiratory system or on a metabolic organ such as the liver, an operation on the brain, except for the brain stem, will not interfere greatly with the viability of the living organism in so far as cardiorespiratory functions are maintained. If the operative procedures are carried out successfully or a massive blood loss is adequately replaced by blood transfusions, most patients tolerate well such long and seemingly aggressive procedures on the brain.

However, the incidence of arrhythmia and postoperative atelectasis, and the mortality rate increased with the duration of surgery. Prolonged anesthesia is hazardous to the life of patients, and often becomes a cause of friction between neurosurgeons and anesthesiologists. The anesthesiologist's long hours of supportive endeavor are often not appreciated either by the anesthetized patient or surgeons, and most of the glory of a "long operation" goes only to

the surgeon.

VI. Postoperative problems

After major surgical intervention, emergence from general anesthesia may be prolonged. The time between the end of the operation and the extubation of the endotracheal tube was studied in more than 13,000 patients. The patients were divided into three age groups: less than 6 years, 6 to 60 years, and over 60 years. There was no noticeable difference in the length of emergence from anesthesia among these groups when there were no neurological disorders attributable to the surgery on the brain.¹¹⁾

Postoperative excitement and cardiovascular shock is often caused by hypoxia. The shock lung syndrome or adult respiratory distress syndrome after massive blood transfusions are well known. Although PaO_2 usually decreased after the operation as shown in Table 4, the use of micropore filters prevented severe respiratory complications to a great extent.

More than half of the patients had increased PaCO_2 while one-fifth had decreased PaCO_2

Table 6 Length of general anesthesia and operations on elderly patients.

	<1 hr	<3	<5	<7	<10	<15	15<	Total
Neuro-surg	0	17	28	15	5	4	0	72
	cases							cases
Anesth.	0	3	15	21	26	4	3	72
Other op.	134	395	289	157	91	29	0	1095
Anesth.	7	275	358	231	151	73	0	1095

Table 7 Stresses on elderly patients.

Blood lost during the operations.

Insignificant	<100 ml	<200	<500	<1000	<3000	<5000	<7000	Total
27 cases	211	130	231	238	247	29	10	1123

Amount of blood transfusion during the operations.

None	<200 ml	<500	<1000	<3000	<5000	<7000	<10000	≥10000	Total
624 cases	10	50	173	221	19	7	1	1	1106

Changes in the pulse pressures during the operations; width between highest and lowest systolic pressures.

<40 mmHg	<60	<80	≥80	Total
164 cases	271	261	419	1115

Among 1,184 cases of over 60 years of age.

Table 8 Preoperative PaCO₂ in geriatric patients undergoing general anesthesia, and postoperative changes.

Age	No.	<30 torr	<35 torr	35-45 torr	<55 torr	≥ 55 torr	Total	Increased	< ± 5 torr	Decreased
60's	472 cases	3.4%	15.7	63.8	15.2	1.9	100%	54.5%	22.2	23.3
70's	287 cases	4.9%	16.0	63.4	13.9	1.8	100%	57.4%	20.6	22.0
80's	27 cases	3.7%	25.9	51.9	18.5	0	100%	46.1%	23.1	30.8

786 cases among 1,184 geriatric general anesthesia cases from July 1, 1975 to June 30, 1978.

of 5 torr or more respectively from their own preoperative values (Table 8). Even if a patient has hypoxia, he usually does not complain of dyspnea due to either neurosurgical consequences or low PaCO₂.

Since the elderly have generally passed their reproductive stage, biological changes specific to the aged are not subject to genetic propagation, and hence do not undergo natural selection in the evolutionary process. The physical reactions seen after stress in the aged are not necessarily beneficial for the well-being of the individual. The postoperative complications are summarized in Table 2.

VII. Considerations concerning PaCO₂

PaCO₂ and the alveolar ventilatory volume ($\dot{V}_A$) are inversely related as shown by the formula:

$$\dot{V}_A(\text{BTPS}) = \frac{V\text{CO}_2}{\text{PaCO}_2} \times 0.863$$

The normal medullary respiratory center is very sensitive to changes in PaCO₂, and controls $\dot{V}_A$ to keep the PaCO₂ at around 40 torr. What then does low PaCO₂ in elderly patients mean? Low PaCO₂ before the operation was often accompanied by low PaO₂. This indicates that hypoxemia was the ventilatory drive. The low PaCO₂ after the operation was usually accompanied by postoperative metabolic acidosis.

These facts show that the threshold of the respiratory center in these elderly patients was rather insensitive to a change of PaCO₂ itself. Therefore, the respiration of these patients was easily depressed and low PaCO₂ often became higher postoperatively. If inadvertent oxygen inhalation should depress the hypoxic respiratory drive, CO₂ narcosis will result. When oxygen inhalation is applied to these patients,

careful observation or mechanical support of ventilation will be mandatory. Mechanical respiratory support will also be useful to prevent postoperative cerebral edema. The importance of deep breathing and postural change to prevent postoperative pulmonary complications resulting in hypoxia and hypercarbia is emphasized again.

Conclusion

The number of operations on elderly patients is still fewer in neurosurgery than that in other surgical fields but will increase as the results of neurosurgical operations are improved. Problems in elderly patients undergoing neurosurgery were discussed from the view point of anesthesiology.

Providing anesthesia for extremely high risk patients needing urgent neurosurgical intervention is also the anesthesiologist's responsibility to his patients. We would like to do our best for the patient's benefit with the full cooperation and understanding of the neurosurgeon.

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