대한중환자의학회지 : 제 22 권 제 1 호
Vol. 22, No. 1, June, 2007

■ 원 저 ■

Statistical Analysis of Mortality Associated with Anesthesia and Surgery in a Hospital from 2000 to 2004

Jiyeon Sim, M.D.*, **Donguk Kim,** Ph.D.†, **Jeong Rim Lee,** M.D.‡ and **Wonsik Ahn,** M.D.‡

*Department of Anesthesiology, College of Medicine, University of Ulsan, Ulsan, †Department of Statistics, Sungkyunkwan University, ‡Department of Anesthesiology, Seoul National University College of Medicine, Seoul, Korea

Background: Surgical patients should be provided adequate information on operation. The information on mortality is extremely important among them. The purposes of this study are to investigate the recent mortality associated with anesthesia and surgery, and to get a logistic regression model of mortality based on patient information.

Methods: We collected all of the anesthetic cases except local anesthesia during 5 years (between 2000 and 2004) in a hospital. All deaths within 7 days after anesthesia were retrieved. These data were analyzed in terms of age, gender, department in charge, time point after anesthesia, elective or emergency surgery, type of anesthesia, operation name, and diagnosis. The combined effects of the variables on the mortality were evaluated with logistic regression. The causes of death were also analyzed.

Results: There were 155 deaths among 74,458 patients under anesthesia. Age less than 1 year old or greater than 80 years old, male gender, department of thoracic surgery, emergency operation, cardiovascular surgery, and diseases for transplantation had higher mortality than their counterparts. Regression model was followed with assignment of '1' for the above mentioned categories. Other categories were designated by '0'.

$$\text{Log}[p\ (\text{death})/\{1-p\ (\text{death})\}] = -9.15+1.03\times\text{age}+0.66\times\text{sex}+0.79\times\text{department}+2.77\times\text{emergency}+2.52\times\text{diagnosis}+0.89\times\text{operation}$$

The leading cause of death was sepsis (21.9%).

Conclusions: The average of mortality within 7 days after anesthesia was 21 per 10,000 anesthetic cases (0.21%). Estimated mortality based on logistic regression ranged from 0.01% to 10.25% depending on patient information.

Key Words: Hospital mortality, Mortality after anesthesia, Mortality after operation, Mortality after surgery

INTRODUCTION

Patients should be given adequate information on the management before any specific complication. They are anxious about surgery and anesthesia because operative procedures may have a high complication rate compared to medical ones. One of the serious surgical complications is mortality. The overall mortality related to anesthesia and surgery was initially reported in 1976.[1] Though there have been some reports on mortality from specific diseases or operations,[2-5] no research has been performed on the mortality associated

Correspondence to : Wonsik Ahn, Department of Anesthesiology, Seoul National University Hospital, 28, Yeongeon-dong, Jongno-gu, Seoul 110-744, Korea. Tel: 82-2-2072-3087, Fax: 82-2-747-5639 E-mail: aws@snu.ac.kr

with anesthesia and surgery during the past 30 years. Nowadays, improvement of medical quality dramatically lessens the intra-operative mortality. The consequence is that most of the hospital deaths occurred in the intensive care unit. It is not easy to differentiate whether the main cause of death is the inherent disease or the anesthesia or operation. However, there are different trends in postoperative mortality in the intensive care unit, so we supposed that the early high mortality was more relevant to operation. The purposes of this study are to investigate the recent comprehensive mortality associated with anesthesia and operation, and to get a logistic regression model of mortality based on patient information.

METHODS

1) Data collection

In this retrospective study, we reviewed all the medical records of operations performed under anesthesia in a 1600-bed University Hospital during the period 2000～2004. Death follow-up was performed until July 2005. The inclusion criteria were operations under general, spinal and/or epidural anesthesia, and nerve block. Procedures under local anesthesia were excluded from this study because they could not be collected by one query method. They were managed by the individual departmental program. We collected data from database of Hospital Electromedical Recording System (HERS), that of the Korean National Statistical Office, and that of Hospital Death Recording System. The three data were indexed and matched by Korean social security number.

2) Data analyses

Deaths within 7 days after operation were retrieved because the nature of death before 7 days seemed to be different from that after 7 days (Fig. 1). The causes of death within 7 days after operation seem to be different from those after 7 days after operation, based on the result that the trend of the mortality before 7 days is different from that after 7 days. We suppose that the early high mortality was more relevant to operation even though this was not supported by any previous study. It is more reasonable to categorize data groups which show similar trends. So, we set up an assumption that the early high mortality is more relevant to operation compared to the disease itself.

Deaths within 7 days after operation were analyzed in terms of age, sex, department in charge, time point after anesthesia, type of operation (emergency or elective), type of anesthesia, operation name, and diagnosis. If there were multiple operations in one patient, we selected only the last operation. The highest ranked operation name and diagnosis were selected from HERS classification. Some data on operation name and/or diagnosis were missed or described using the simple text. They were categorized as “unidentified” because they could not be classified by the electromedical re-

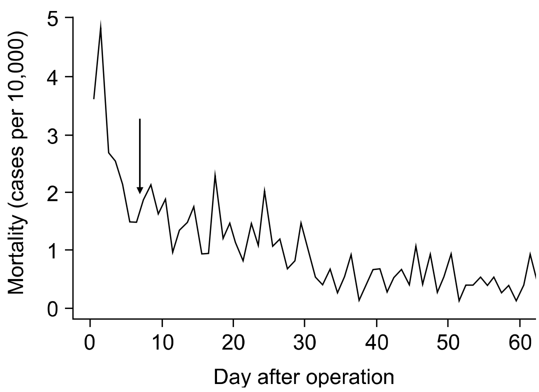

Fig. 1. The changes of mortality for 74458 anesthetic cases in terms of time point after operation (day). The arrow indicates 7 days after operation. The causes of death within 7 days after operation seem to be different from those after 7 days after operation, based on the result that the trend of the mortality before 7 days is different from that after 7 days. We suppose that the early high mortality is more relevant to operation even though this is not supported by any previous study. It is more reasonable to categorize data groups which show similar trends. So, we set up an assumption that the early high mortality is more relevant to operation compared to the disease itself.

cording code.

The combined effects of the variables on the mortality were evaluated with logistic regression. A final logistic model was made by the stepwise selection method.

Also, the causes of mortality were classified based on operation record, anesthesia record, and intensive care unit nursing chart.

3) Statistical analyses

All of statistical comparisons were made with the chi-square test. Logistic regression was performed to evaluate the combined effects of the variables. The stepwise selection method was adopted to make a final model. $p<0.05$ was considered significant. Statistical analyses were conducted using SAS™ version 9.01 (SAS Korea, Seoul, Korea).

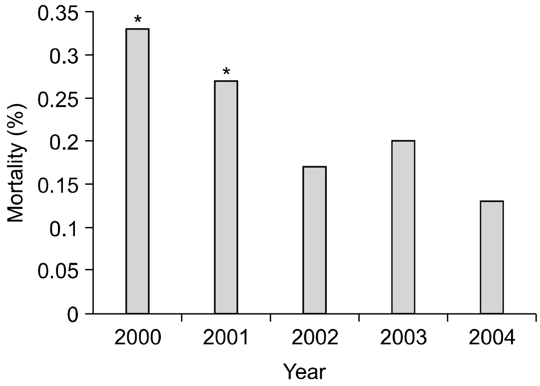

Fig. 2. Mortality during the period 2000-2004. Years 2000 and 2001 revealed different mortality from other years (0.33% in 2000 and 0.27% in 2001 vs. 0.17% in 2002, 0.20% in 2003, and 0.13% in 2004, $^*p<0.05$). This result may be due to a strike of Korean physicians in 2000.

RESULTS

1) Descriptive statistics

A total of 74458 operations were performed under anesthesia during the period 2000～2004, and 155 patients died within 7 days after operation. The mortality was 21 per 10,000 anesthetic cases. The mortality of 2000 and 2001 were higher than the others (0.33% in 2000, 0.27% in 2001 vs. 0.17% in 2002, 0.20% in 2003, and 0.13% in 2004; $p<0.05$) (Fig. 2).

The mortality was higher in infant and old age groups (0.90%, less than 1 year old; 0.53%, greater than 80 years old). School-age children showed the lowest mortality (0.07%). The details of mortality in terms of age are shown in Table 1.

The mortality in terms of gender was 0.16% higher in male than in female (0.29% vs. 0.13%; $p<0.05$). The mortality in males was more than twice as high as that in females each year except in 2000 when a strike of Korean physicians took place. The details of mortality in terms of gender are shown in Table 2.

Relatively high mortality was noted in the departments of pediatric (1.56%) and adult (0.77%) thoracic surgery. Relatively low mortality was observed in the departments of urology (0.05%), obstetric and gynecology (0.04%), and otorhinolaryngology (0.03%). The mortality of 0% was found for pediatric cases in all departments except the departments of thoracic surgery and general surgery. The department of ophthalmology had the mortality of 0% for pediatric and adult cases during the 5 years. The details of mortality in terms of department in charge are shown in Table 3.

The mortality in terms of time point after anesthesia was higher at the day of operation and at 1 day after operation than at other days after operation (18% and 23% vs. 7～13%; $p<0.05$). The details of mortality in terms of time point after anesthesia are shown in Table 4.

The mortality for emergency operation was 15 times as high as that for elective one (0.97% vs. 0.06%; $p<0.05$). The details of mortality in terms of the type of operation are shown in Table 5.

The mortality after operation was 0.15 % higher in cases under general anesthesia than in cases under epidural anesthesia, spinal anesthesia, or brachial plexus block (0.23% vs. 0.08%, 0.07%, and 0%; $p<0.05$). One patient under spinal anesthesia died each year during the 5 years except 2 in 2001, and one patient under epidural anesthesia died in 2004. The details of

Table 1. Mortality in Terms of Age

Age (yrs)	2000	2001	2002	2003	2004	5-year total
0～1	11/519 (2.12%)	8/624 (1.28%)	1/506 (0.20%)	4/589 (0.68%)	2/639 (0.31%)	26/2,877 (0.90%)*
1～9	3/1,740 (0.17%)	2/2,525 (0.08%)	3/2,672 (0.11%)	2/2,809 (0.07%)	2/2,873 (0.07%)	12/12,619 (0.10%)
10～19	1/802 (0.12%)	1/1,029 (0.10%)	0/1,148 (0%)	1/1,282 (0.08%)	1/1,390 (0.07%)	4/5,651 (0.07%)
20～29	3/909 (0.33%)	2/1,174 (0.17%)	4/1,336 (0.30%)	3/1,352 (0.22%)	0/1,431 (0%)	11/6,202 (0.18%)
30～39	2/1,181 (0.17%)	5/1,463 (0.34%)	0/1,744 (0%)	3/1,972 (0.15%)	2/2,073 (0.10%)	12/8,433 (0.14%)
40～49	3/1,531 (0.20%)	5/2,187 (0.23%)	4/2,521 (0.16%)	2/2,818 (0.07%)	3/3,030 (0.10%)	17/12,087 (0.14%)
50～59	4/1,514 (0.26%)	4/2,058 (0.19%)	3/2,132 (0.14%)	7/2,523 (0.28%)	2/2,804 (0.07%)	20/11,031 (0.18%)
60～69	3/1,301 (0.23%)	6/1,793 (0.33%)	6/1,999 (0.30%)	7/2,589 (0.27%)	8/2,911 (0.27%)	30/10,593 (0.28%)
70～79	3/466 (0.64%)	3/650 (0.46%)	5/808 (0.62%)	4/1,035 (0.39%)	2/1,258 (0.24%)	17/4,217 (0.40%)
＞80	0/82 (0%)	1/100 (1.00%)	0/117 (0%)	1/198 (0.51%)	2/251 (0.80%)	4/748 (0.53%)*
Total	33/10,045 (0.33%)	37/13,603 (0.27%)	26/14,983 (0.17%)	34/17,167 (0.20%)	25/18,660 (0.13%)	155/74,458 (0.21%)

Values represent deaths within 7 days after operation over total procedures. *: $p < 0.05$ vs. other age groups.

Table 2. Mortality in Terms of Gender

	2000	2001	2002	2003	2004	5-year total
Female	16/5,129 (0.31%)	11/6,949 (0.16%)	7/7,761 (0.09%)	10/8,884 (0.11%)	6/9,768 (0.06%)	50/38,491 (0.13%)
Male	17/4,916 (0.35%)	26/6,654 (0.39%)	19/7,222 (0.26%)	24/8,283 (0.29%)	19/8,892 (0.21%)	105/35,967 (0.29%)*
Total	33/10,045 (0.33%)	37/13,603 (0.27%)	26/14,983 (0.17%)	34/17,167 (0.20%)	25/18,660 (0.13%)	155/74,458 (0.21%)

Values represent deaths within 7 days after operation over total procedures. *: $p < 0.05$ vs. female.

Table 3. Mortality in Terms of Department in Charge

	2000	2001	2002	2003	2004	5-year total
TS (child)	7/189 (3.70%)	6/412 (1.46%)	0/172 (0%)	2/138 (1.45%)	1/117 (0.85%)	16/1,028 (1.56%)*
TS (adult)	6/507 (1.18%)	7/662 (1.06%)	4/660 (0.61%)	2/597 (0.34%)	5/685 (0.73%)	24/3,111 (0.77%)*
NS	1/529 (0.19%)	0/756 (0%)	8/807 (0.99%)	5/794 (0.63%)	3/825 (0.36%)	17/3,711 (0.46%)
GS (child)	3/587 (0.51%)	2/752 (0.27%)	3/779 (0.39%)	3/843 (0.36%)	4/844 (0.47%)	15/3,805 (0.39%)
GS (adult)	12/2,398 (0.50%)	17/3,033 (0.56%)	9/3,530 (0.25%)	15/4,259 (0.35%)	9/4,615 (0.20%)	62/17,835 (0.35%)
OS	1/1,191 (0.08%)	2/1,442 (0.14%)	1/1,589 (0.06%)	7/1,687 (0.41%)	1/1,775 (0.06%)	12/7,684 (0.16%)
URO	1/502 (0.20%)	0/713 (0%)	0/786 (0%)	0/946 (0%)	1/1,116 (0.09%)	2/4,063 (0.05%)
OG	0/1,093 (0%)	2/1,490 (0.13%)	1/1,841 (0.05%)	0/1,912 (0%)	0/1,954 (0%)	3/8,290 (0.04%)
OL	2/1,034 (0.19%)	0/1,579 (0%)	0/1,877 (0%)	0/2,076 (0%)	1/2,107 (0.05%)	3/8,673 (0.03%)
Others	0/2,015 (0%)	1†/2764 (0.04%)	0/2942 (0%)	0/3915 (0%)	0/4622 (0%)	1/16,258 (0.01%)
Total	33/10,045 (0.33%)	37/13,603 (0.27%)	26/14,983 (0.17%)	34/17,167 (0.20%)	25/18,660 (0.13%)	155/74,458 (0.21%)

Values represent deaths within 7 days after operation over total procedures. TS: thoracic surgery, NS: neurosurgery, GS: general surgery, OS: orthopedic surgery, URO: urology, OG: obstetric and gynecology, OL: otorhinolaryngology. *: $p<0.05$ vs. other departments, †: plastic surgery. The mortality for pediatric cases was 0% except for TS and GS. The mortality for the Department of Ophthalmology was 0% during the 5 years.

mortality in terms of the type of anesthesia are shown in Table 6.

The mortality in terms of operation name was higher in cardiovascular system operation (1.23%) than in other system operations (0.12～0.46%). Some operation names were missed or described using the simple text instead of the operation code. In this study, they were categorized as "unidentified operation" because they could not be classified by the electromedical recording code. The details of mortality in terms of operation name are shown in Table 7.

The mortality in terms of diagnosis was higher in diseases requiring transplantation (2.82%) and in neonatal diseases (2.04%) than in other diseases (0.06～1.58%). Some diagnoses were also missed because of the same reason as the operation name. The details of mortality in terms of diagnosis are shown in Table 8.

2) Prediction of mortality

Logistic regression test with stepwise selection re-

Table 4. Mortality in Terms of Time Point after Operation

	2000	2001	2002	2003	2004	5-year total
Operation day	10 (30%)*	6 (16%)	4 (15%)	7 (21%)	1 (4%)	28 (18%)†
Postoperative 1 day	6 (18%)	12 (32%)	3 (12%)	8 (24%)	7 (28%)	36 (23%)†
Postoperative 2 days	5 (15%)	6 (16%)	1 (4%)	5 (15%)	3 (12%)	20 (13%)
Postoperative 3 days	2 (6%)	3 (8%)	6 (23%)	2 (6%)	6 (24%)	19 (12%)
Postoperative 4 days	3 (9%)	5(14%)	2 (7%)	3 (9%)	3 (12%)	16 (10%)
Postoperative 5 days	1 (3%)	2 (5%)	6 (23%)	1 (3%)	1 (4%)	11 (7%)
Postoperative 6 days	3 (9%)	1 (3%)	1 (4%)	4 (12%)	2 (8%)	11 (7%)
Postoperative 7 days	3 (9%)	2 (5%)	3 (12%)	4 (12%)	2 (8%)	14 (9%)
Total	33 (100%)	37 (100%)	26 (100%)	34 (100%)	25 (100%)	155 (100%)

Values represent deaths after operation. *: Percent (%) was calculated separately in each year. †: $p<0.05$ vs. other time points.

Table 5. Mortality in Terms of Emergency or Elective Operation

	2000	2001	2002	2003	2004	5-year total
Emergency operation	22/1,098 (2.00%)	24/1,374 (1.76%)	20/1,884 (1.06%)	32/4,280 (0.75%)	18/3,359 (0.54%)	116/11,995 (0.97%)*
Elective operation	11/8,947 (0.12%)	13/12,229 (0.11%)	6/13,099 (0.05%)	2/12,885 (0.02%)	7/14,294 (0.05%)	39/62,463 (0.06%)
Total	33/10,045 (0.33%)	37/13,603 (0.27%)	26/14,983 (0.17%)	34/17,167 (0.20%)	25/18,660 (0.13%)	155/74,458 (0.21%)

Values represent deaths within 7 days after operation over total procedures. *: $p<0.05$ vs. elective operation.

vealed significant correlations in the variables, including age, gender, department in charge, emergency operation, diagnosis, and operation name ($p<0.05$). The type of anesthesia was dropped in logistic regression analysis ($p>.05$). Regression model was followed with assignment of '1' for age less than 1 year or greater than 80 years, male gender, department of thoracic surgery, emergency operation, diseases requiring transplantation or neonatal disease, and cardiovascular operation. Other categories were designated by '0'.

$$\text{Log}[p\ (\text{death})/\{1-p\ (\text{death})\}] = -9.15 + 1.03 \times \text{age} + 0.66 \times \text{sex} + 0.79 \times \text{department} + 2.77 \times \text{emergency} + 2.52 \times \text{diagnosis} + 0.89 \times \text{operation}$$

Low prediction of mortality (0.01%) by logistic regression is plausible. However, the highest prediction of mortality (37.97%) on theoretical (all categories='1') logistic regression is hardly possible because diseases requiring transplantation or neonatal disease and cardiovascular operation could not be selected in a patient. In practice, emergency liver transplantation in a male infant records the highest mortality (10.25%). Estimated mortality based on logistic regression ranged from 0.01% to 10.25%.

3) Causes of mortality

Causes of death estimated by surgeon's record, anesthesia record and intensive care nursing record revealed

Table 6. Mortality in Terms of the Type of Anesthesia

	2000	2001	2002	2003	2004	5-year total
General anesthesia	32/8,520 (0.38%)	35/11,770 (0.30%)	25/13,096 (0.19%)	33/15,025 (0.22%)	23/16,123 (0.14%)	148/64,534 (0.23%)*
Epidural anesthesia	0/182 (0%)	0/117 (0%)	0/218 (0%)	0/359 (0%)	1/411 (0.24%)	1/1,287 (0.08%)
Spinal anesthesia	1/1,343 (0.07%)	2/1,660 (0.12%)	1/1,563 (0.06%)	1/1,679 (0.06%)	1/2,006 (0.05%)	6/8,251 (0.07%)
Brachial plexus block	0/0 (0%)	0/56 (0%)	0/106 (0%)	0/104 (0%)	0/120 (0%)	0/386 (0%)
Total	33/10,045 (0.33%)	37/13,603 (0.27%)	26/14,983 (0.17%)	34/17,167 (0.20%)	25/18,660 (0.13%)	155/74,458 (0.21%)

Values represent deaths within 7 days after operation over total procedures. *: $p < 0.05$ vs. other types of anesthesia.

the highest in multi-organ failure by sepsis (34 cases in 155 total cases, 21.9%). The second cause of mortality is multi-organ failure by perioperative hypovolemia (21 cases, 13.5%). Another causes are composed of brain damage including acute cerebral infarction and increased intracranial pressure (18 cases, 11.6%), acute heart failure including acute myocardial infarction (12 cases, 7.7%), acute respiratory failure including acute respiratory distress syndrome (6 cases, 3.87%), acute renal failure and relating multi-organ failure (4 cases, 2.58%), and acute fulminant hepatic failure (2 cases, 1.29%). Other indirectly relating causes after operation is bilateral pneumothorax during central venous catheterization, hemothorax, airway obstruction by aspiration, stomach ulcer bleeding, and bronchial bleeding. There were 53 cases which had inadequate medical record for the analysis of cause of death.

DISCUSSION

The mortality associated with anesthesia and operation was dramatically reduced nowadays compared to that during the period 1966～1970, though its time point analysis after operation was much longer than that of the previous research (0.21% during the period 2000～2004, 7-day analysis vs. 2.6% during the period 1966～1970, 1-day analysis).[1] The reason for this decrease would be due to better conditions of patients, improved transportation system, a remarkable development of operative technique, a significant advance in the monitoring system and other anesthesia-related devices, and highly educated medical professionals including surgeons, anesthesiologists, and intensive care nurses. The medical records in 2000 when a strike of Korean physicians took place showed different results in the overall mortality and the mortality in terms of gender, department in charge, and type of operation. It would affect the high mortality of the next year considering education is important in medical practice (Fig. 2). Research regarding this issue could help the study on medical complications or inadequate treatment caused by human resource.

The high perioperative mortality in infants (0.90%) may be due to congenital heart diseases (Tables 1 and 3). The mortality in males was more than twice as high as that in females except in 2000 when a strike of Korean physicians took place (Table 2). This result is in a good agreement with that of previous studies.[1,6] Thirty years ago, the highest mortality was reported at the department of neurosurgery, but it was recently reported at the department of thoracic surgery

Table 7. Mortality in Terms of Operation Name

	2000	2001	2002	2003	2004	5-year total
Cardiovascular system operation	11/489 (2.25%)	8/758 (1.06%)	6/516 (1.16%)	3/528 (0.57%)	7/583 (1.20%)	35/2,874 (1.23%)*
Digestive system operation	11/2,201 (0.50%)	17/2,667 (0.64%)	12/2,947 (0.41%)	17/3,246 (0.52%)	9/3,382 (0.27%)	66/14,443 (0.46%)
Nervous system operation	2/549 (0.36%)	1/725 (0.14%)	6/805 (0.75%)	5/877 (0.57%)	3/864 (0.35%)	17/3,820 (0.45%)
Respiratory system operation	3/464 (0.65%)	2/743 (0.27%)	0/770 (0%)	1/809 (0.12%)	3/757 (0.40%)	9/3,543 (0.25%)
Soft tissue or musculoskeletal operation	3/1,887 (0.16%)	4/2,371 (0.17%)	1/2,540 (0.04%)	6/2,709 (0.22%)	1/2,744 (0.04%)	15/12,251 (0.12%)
Other operation	Urinary 2/434 (0.46%)	Urinary 1/654 (0.15%) Obstetric 1/100 (1%)	–	Dental 2/27 (7.41%)	Urinary 1/896 (0.10%) Dental 1/136 (0.74%)	8/2,247 (0.36%)
0% mortality operation†	3,688	5,124	6,847	8,362	7,695	31,716
Unidentified operation‡	1/333 (0.30%)	3/461 (0.65%)	1/558 (0.18%)	0/609 (0%)	0/1,603 (0%)	5/3,564 (0.14%)
Total	33/10,045 (0.33%)	37/13,603 (0.27%)	26/14,983 (0.17%)	34/17,167 (0.20%)	25/18,660 (0.13%)	155/74,458 (0.21%)

Values represent deaths within 7 days after operation over total procedures. *: $p < 0.05$ vs. other operation names, †: The mortality from the operations of the endocrine system, ear, eye, female genital organ, hematopoietic/lymphatic system, male genital organ, nose, mouth, pharynx, spinal cord, spinal canal structure, and the therapeutic radiologic procedures. ‡: Some operation sites or names were missed or described using the simple text. They were categorized as "unidentified operation" because they could not be classified by the electromedical recording code.

(Table 3). Deaths at the day of operation and at 1 day after operation accounted for 50% of the overall mortality after surgery (51%, Table 4). The mortality for emergency operation was more than 10 times as high as that for elective operation (Table 5). This result is in accordance with that of previous studies.[1,6] Higher mortality from general anesthesia may be due to the anesthesiologist's preference for general anesthesia for patients under poor conditions (Table 6). This might be the reason why the type of anesthesia was dropped in logistic regression analysis. Pediatric and adult heart surgeries appear to be responsible for higher mortality from cardiovascular operations (Tables 1, 3, and 7). The highest mortality from the diseases for transplantation may be due to liver transplantation (Table 8).

Low prediction of mortality (0.01%) by logistic regression is plausible. However, the highest prediction of mortality (37.97%) on theoretical (all categories='1') logistic regression is hardly possible because diseases requiring transplantation or neonatal disease and cardiovascular operation could not be selected in a patient in practice.

Table 8. Mortality in Terms of Diagnosis

	2000	2001	2002	2003	2004	5-year total
Disease for transplantation	1/4 (25%)	2/16 (12.5%)	0/21 (0%)	1/39 (2.56%)	0/62 (0%)	4/142 (2.82%)*
Neonatal disease	0/13 (0%)	1/23 (4.35%)	0/29 (0%)	2/38 (5.26%)	0/44 (0%)	3/147 (2.04%)
Cardiovascular disease	9/390 (2.31%)	11/602 (1.83)	5/395 (1.27%)	3/404 (0.74%)	8/483 (1.66%)	36/2,274 (1.58%)
Hematologic disease	1/35 (2.86%)	1/54 (0.65%)	1/46 (2.17%)	0/63 (0%)	0/51 (0%)	3/249 (1.20%)
Infectious disease	1/74 (1.35%)	0/103 (0%)	0/111 (0%)	0/123 (0%)	3/141 (2.13%)	4/552 (0.72%)
Nervous system disease	2/387 (0.52%)	0/520 (0%)	7/593 (1.18%)	5/614 (0.81%)	2/655 (0.31%)	16/2,769 (0.58%)
Digestive disease	3/805 (0.37%)	8/1000 (0.80%)	5/1,040 (0.48%)	5/1,040 (0.48%)	5/1,301 (0.38%)	26/5,186 (0.50%)
Endocrine disease	1/40 (2.5%)	0/71 (0%)	0/70 (0%)	0/85 (0%)	0/108 (0%)	1/374 (0.27%)
Environmental disease	1/177 (0.56%)	1/154 (0.65%)	0/243 (0%)	0/242 (0%)	1/371 (0.27%)	3/1,187 (0.25%)
Urologic disease	1/374 (0.27%)	0/564 (0%)	0/605 (0%)	2/684 (0.29%)	1/738 (0.14%)	4/2,965 (0.13%)
Respiratory disease	1/245 (0.41%)	1/426 (0.23%)	0/396 (0%)	0/388 (0%)	0/297 (0%)	2/1,752 (0.11%)
Neoplasm	4/2,574 (0.16%)	3/3,586 (0.08%)	1/4,139 (0.02%)	3/4,683 (0.06%)	2/5,130 (0.04%)	13/20,112 (0.06%)
Musculoskeletal disease	1/607 (0.16%)	0/595 (0%)	0/709 (0%)	1/671 (0.15%)	0/953 (0%)	2/3,535 (0.06%)
No mortality diagnosis†	1,314	1,934	1,958	2,350	3,261	10,817
Unclassified diagnosis‡	7/3,096 (0.23%)	9/4,026 (0.22%)	7/4,698 (0.15%)	12/5,828 (0.21%)	3/5,173 (0.06%)	33/22,690 (0.15%)
Total	33/10,045 (0.33%)	37/13,603 (0.27%)	26/14,983 (0.17%)	34/17,167 (0.20%)	25/18,660 (0.13%)	155/74,458 (0.21%)

*: $p < 0.05$ vs. other diseases, †: The mortality for diagnoses, including eye diseases, female genital diseases and pregnancy complications, immunologic diseases, nutritional and metabolic diseases, oral cavity and tooth diseases, otorhinolaryngologic diseases, psychiatric diseases, skin and connective tissue diseases, and stomatognathic diseases was 0%. ‡: Some diagnoses were missed or described using the simple text. They were categorized as "unclassified diagnosis" because they could not be classified by the electromedical recording code.

A previous study on peri-operative mortality associated with anesthesia and operation reported that there were 570 deaths among 325,585 procedures within 3 days after operation in Finland in 1986 (0.18%), and that operation was the main contributing factor in the death of 22 (0.68 per 10,000 cases), and anesthesia in the death of 5 (0.15 per 10,000 cases).[7] The overall mortality within 7 days after operation due to all etiologies and the exclusively attributed to anesthesia in Japan in 1998 was 7.18 and 0.21 per 10,000 cases, respectively.[8] The incidence of 24-h postoperative death was 8.8 per 10,000 anesthetic cases and that of 24-h postoperative coma was 0.5 per 10,000 anesthetic cases in America.[9]

The limitations of this study are that only one hospital was surveyed and that it was a retrospective study. There was no information about causes of death, anesthesia or surgery. There were many missing data in diagnosis and operation name. So, this result could not represent nationwide mortality rate. Even though it was not a multi-center study, nor a prospective one, it is valuable because there have been no adequate information on the Korean surgical mortality for 30 years, and the operation cases were more than 70 thousands. This information could be used for patient explanation for operation and for the peri-operative quality improvement study.

In conclusion, the mortality within 7 days after operation during the period 2000∼2004 was 0.21%. Estimated mortality based on logistic regression ranged from 0.01% to 10.25% depending on patient information.

ACKNOWLEDGEMENTS

We thank Misun Lim, and Sunhwa Yang for their help to prepare this paper.

RERFERENCES

1) Chang SC, Chung KS, Lee SH: Statistical analysis of the postoperative mortality. Korean J Anesthesiol 1976; 9: 107-11.
2) Park SJ, Ryu SJ, Kim KH, Jang TH, Kim SH: Determinants of postoperative mortality after pneumonectomy. Korean J Anesthesiol 1996; 31: 777-81.
3) Lim ES, Han JI, Kim CH, Lee GY, Kang SY: Morbidity and mortality analysis after noncardiac surgery in patients with prior myocardial infarction. Korean J Anesthesiol 2005; 49: 321-6.
4) Lee KH, Hwang SJ, Kim SH, Lee SH, Yu DK, Hwang JH, et al: Comparison of mortality and morbidity in multiple versus singleton very low birth weight infants in a neonatal intensive care unit. J Korean Med Sci 2003; 18: 779-82.
5) Bae YM, Bae CW: The changes in the mortality rates of low birth weight infant and very low birth weight infant in Korea over the past 40 years. J Korean Med Sci 2004; 19: 27-31.
6) Fleisher LA: Risk of anesthesia. In: Miller's anesthesia. 6th ed. Edited by Miller RD: Philadelphia, Elsevier. 2005, pp 893-925.
7) Tikkanen J, Hovi-Viander M: Death associated with anaesthesia and surgery in Finland in 1986 compared to 1975. Acta Anaesthesiol Scand 1995; 39: 262-7.
8) Kawashima Y, Takahashi S, Suzuki M, Morita K, Irita K, Iwao Y, et al: Anesthesia-related mortality and morbidity over a 5-year period in 2,363,038 patients in Japan. Acta Anaesthesiol Scand 2003; 47: 809-17.
9) Arbous MS, Meursing AE, van Kleef JW, de Lange JJ, Spoormans HH, Touw P, et al: Impact of anesthesia management characteristics on severe morbidity and mortality. Anesthesiology 2005; 102: 257-68.