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ORIGINAL ARTICLE - NEUROSURGERY GENERAL

Impact of system approach and personal performance on preventable morbidity and mortality events in neurosurgery patients

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Abstract

Purpose Adverse events in neurosurgery are a serious problem. The approach for seeking solutions for adverse events has shifted from a personal approach to a systemic approach. However, to some extent, preventable morbidity events could be related to personal performance. This study aimed to clarify the impact of personal performance and systematic failure on the occurrence of morbidity and mortality events in neurosurgery patients.

Methods All morbidity and mortality conference data stored within our department over a 9-year period were analyzed. There were 4580 admitted patients and 3262 surgical procedures performed. We performed a three-step classification of morbidity and mortality events based on the possibility of prevention, root of the event, and personal or systemic issues.

Results As a result of the first step, 214 preventable and 278 unpreventable events were identified. Of the preventable events, two mortality and 212 morbidity events were analyzed. In the second step, 155 (72.4%), 34 (15.9%), 13 (6.1%), and 12 (5.6%) events were categorized as technical complications, critical events, judgment errors, and human factors, respectively. There were 179 events (83.6%) classified as personal performance issues and 35 events (16.4%) as systemic issues. The ratio of personal performance to systemic issues varied widely, with significant differences among the four categories ($P < 0.01$).

Conclusions Among neurosurgery patients who have preventable morbidity, issues related to personal performance were more frequent than systemic issues. Efforts to improve systems should be unwavering. However, the personal responsibility of neurosurgeons to avoid preventable complications should not be ignored.

Keywords Morbidity event · Neurosurgery · Personal responsibility · System

Introduction

Adverse events in neurosurgery have been widely accepted as a serious problem [6, 17]. Considerable efforts have been made to find solutions for improving patient safety. Recently, several quality control systems have been developed to reduce morbidity and mortality [2, 4, 10]. The literature tends to focus on system failures, rather than personal failures, when exploring the causes of adverse events [3]. However, some preventable morbidity events could be related to personal performance, such as technical failure due to lack of skill, lack of experience, or judgment mistakes. Therefore, for such morbidity events, prevention by system development may be difficult. This study aimed to classify morbidity and mortality events based on the ability to prevent them in neurosurgery. Second, we aimed to classify all morbidity and mortality events based on the root cause. Therefore, all morbidity events could be categorized into four categories: technical complications, critical events, judgment errors, and human factors. Finally, we aimed to clarify the impact of personal performance and systematic failure on the occurrence of morbidity events based on a patient database from morbidity and mortality conferences (MMCs). We hypothesized that personal performance issues may be more prevalent than systemic deficits in neurosurgery. It is fundamental to understand the impact of personal performance and system problems on morbidity and mortality events to prevent repetition of preventable errors.

This article is part of the Topical Collection on *Neurosurgery general*

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Methods

Ethical

This study was approved by the Institutional Review Board of our institution and was conducted according to the principles of the Declaration of Helsinki. This study was an analysis of a prospective database of MMCs at our institution. Informed consent was obtained from patients using the opt-out method on our institutional website. In accordance with the ethical standards of the institutional research committees, this non-invasive study did not require formal consent. Instead, the outline of the study was open to the public on our institutional homepage and provided an option for patients and their guardians to decline inclusion in the research.

Setting

Our hospital is a 612-bed general hospital. The Department of Neurosurgery at our hospital is the largest neurosurgical unit in our prefecture. Our main therapeutic targets include brain tumors, cerebrovascular disease, endovascular therapy, spinal trauma, pediatric surgery, and functional neurosurgery. Chemotherapy for malignant brain tumors was administered in our department. Digital subtraction angiography and endovascular treatment were performed by certified neurosurgeons in our department.

Patient and data acquisition

In this study, all data of MMCs stored within our department over a 9-year period (January 2013 to December 2021) were analyzed. MMCs were held 18 times during the study period and included all admitted patients. The detailed method of our MMCs has been reported earlier [9]. During the study period, 4580 patients were admitted and 3262 surgical procedures were performed. The preventability, root of cause, and solutions of each event were discussed by all participants of the prospective MMCs.

Definition of morbidity and mortality event

The definitions of morbidity and mortality events discussed at our MMCs are as follows. Mortality events were associated with all deaths. We reviewed all patients who died during admission in our MMCs, but from the characteristics of this study, inevitable events and severe diseases (for example, grade V subarachnoid hemorrhage, huge intracerebral hematoma, or high-grade glioma) were excluded. Morbidity was defined as new adverse events that required additional treatment or longer hospitalization than expected. The definition of a morbidity event in the current study included not only errors but also unpreventable or unpredictable complications. As such, our definition of morbidity events included a wider range of events than those generally referred to as "mistakes."

Data analysis

In this study, we performed a three-step classification of morbidity and mortality events based on the possibility of prevention, root of the event, and personal or systemic issues (Fig. 1). In the first step, morbidity and mortality events were classified into two categories: "preventable" and "unpreventable," based on the possibility of prevention in each event. The definitions of preventable and unpreventable events were referred to the methods reported by Houkin et al. [7]. Therefore, when a correct procedure could be recommended to prevent the event, the event was classified as preventable.

In the second step, preventable events were classified based on the root cause of the event. Therefore, all morbidity events fell into four categories: technical complications, critical events, judgment errors, and human factors. This classification method was referred to previous reports with some modifications [6, 15]. The definition of each category was determined as follows. Technical complications comprised a broad category of adverse events involving procedural failure. These complications included errors due to surgery-related event including lack of experience and skill. Those were related to a procedure resulting in postoperative infection, postoperative bleeding, cerebrospinal fluid leak, injury to adjacent structures, re-operation, or another occurrence.

Critical events were indirectly associated with surgery and potentially included postoperative medical morbidity. Neurosurgical treatment may have been successful in critical events, but patients had negative results. Examples of this category include acute coronary syndrome, acute renal failure, pulmonary embolism, pneumoniae, and other systemic problems. Judgment errors were a direct result of surgical decision-making, inaccurate assessment of the risk–benefit of a disease, and patient selection. This type of error included patient selection error, inappropriate choice of treatment method, medical management error, misdiagnosis, and poor device selection. Human factors included human errors such as miscommunication, overlooked, omission, and misunderstanding.

Finally, morbidity and mortality events were classified into two categories based on etiology: systemic or personal issues. The frequencies of each category were calculated and compared.

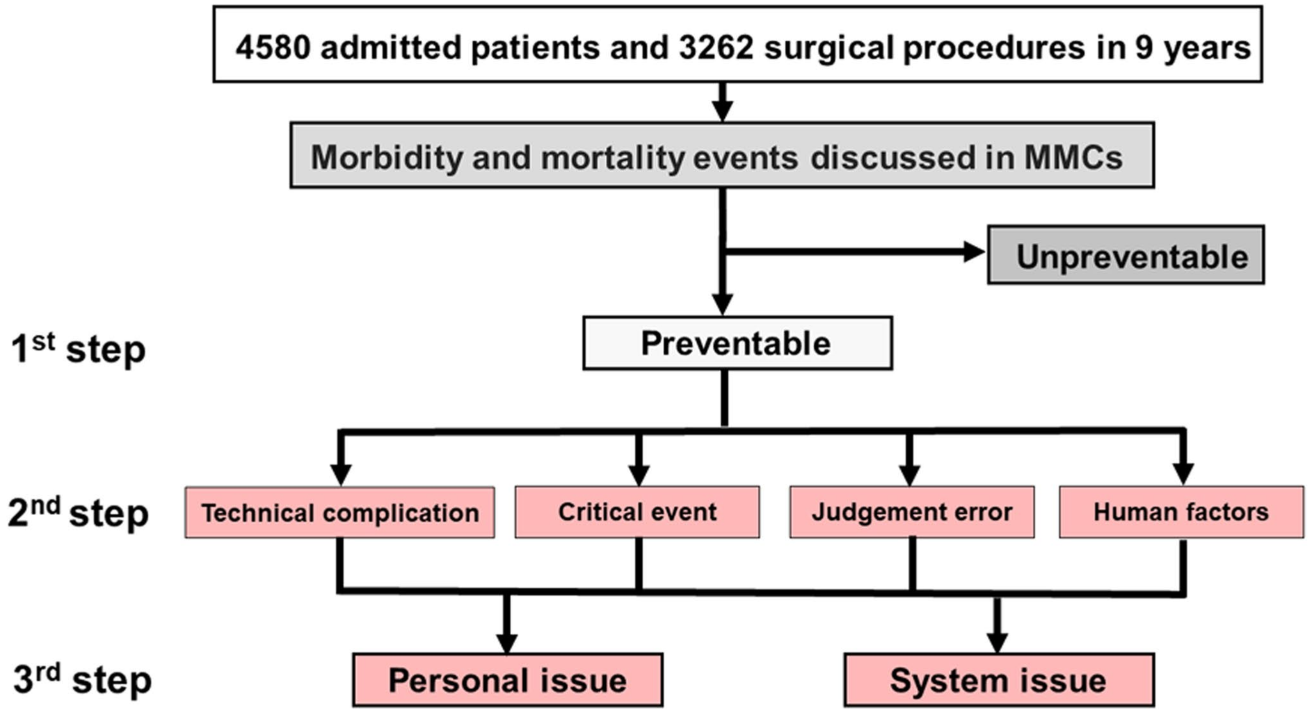

Fig. 1 Three-step classification of morbidity and mortality events. All events are classified by the possibility of prevention, root of event, and personal or systemic issue

Statistical analysis

Continuous data are expressed as mean ± standard deviation. Data between subgroups were compared using the Fisher's exact test, as appropriate. *P* values < 0.05 were considered significant. Statistical analyses were performed using GraphPad Prism version 9.1.0 (GraphPad Software, San Diego, CA, USA).

Results

A total of 4580 patients were admitted to the Department of Neurosurgery, and 3262 surgical or endovascular procedures were performed during the study period. According to our definitions, 98 mortality (2.1% per patient) and 394 morbidity events (8.6% per patient) were discussed in MMCs over the 9-year period. Of these, 96 mortality events (97.9%) were associated with disease severity (e.g., grade V subarachnoid hemorrhage, huge intracerebral hemorrhage, or high-grade glioma) and categorized as unpreventable events. Therefore, two mortality events (2.1%) were included in this study. Of the 394 morbidity events, 182 (46.2%) were excluded from this study because they were categorized as unpreventable. In the first step, 214 preventable and 278 unpreventable events were identified, and two mortality events and 212 morbidity events were analyzed in the second step, in which 155 (72.4%), 34 (15.9%), 13 (6.1%), and 12 (5.6%) events were categorized as technical complications, critical events, judgment errors, and human factors, respectively. Examples and frequency from each category are listed in Table 1. The details of each category and results of the third step are presented below.

Technical complication

This category included errors due to surgery-related lack of experience and skill. Typical technical complications included postoperative bleeding, injury to normal structures such as brain contusion or cranial nerve palsy, ischemia, surgical wound complications, distal embolism or groin hematoma in endovascular treatment, and incomplete treatment. An illustrative case of this type is presented in Fig. 2. Technical errors were the most frequent among the four categories (72.4%). A total of 146 (94.2%) of 155 technical issues were classified as personal performance issues, and only nine were classified as systemic issues.

Critical events

Neurosurgical treatment may have been successful in these events, but patients experienced negative results. Critical events are those that may not directly affect the goals of the procedure but still involve negative outcomes

Table 1 The example of each category and their frequency

	Technical complication (*N*=155)	Critical event (*N*=34)	Judgment error (*N*=13)	Human factors (*N*=12)
Example	Post operative bleeding 23	Acute coronary syndrome 3	Patients selection error 4	Communication error 4
	Injury to normal structure 75	Acute heart failure 3	Mischoice of treatment method 5	Inadequate protocol 4
	Incomplete treatment 8	Acute heart failure 3	Medical management error 2	Failure to implement protocol 4
	Groin hematoma(endovascular) 18	Acute renal failure 2	Misdiagnosis 2	
	Vessel perforation (endovascular) 4	Pulmonary embolism 4		
	Post operative cerebrospinal fluid leakage 8	Pneumonia 4		
	Brain abcess, meningitis 10	Urinary infection 2		
	Shunt infection/shunt dysfunction 9	Gastrointestinal bleeding 4		
		Bilinary infection 4		
		Hemorrhagic complications caused by antiplatelet or anticoagulate drug 3		
		Ischemic complications by caused antiplatelet or anticoagulate drug withdraw 3		

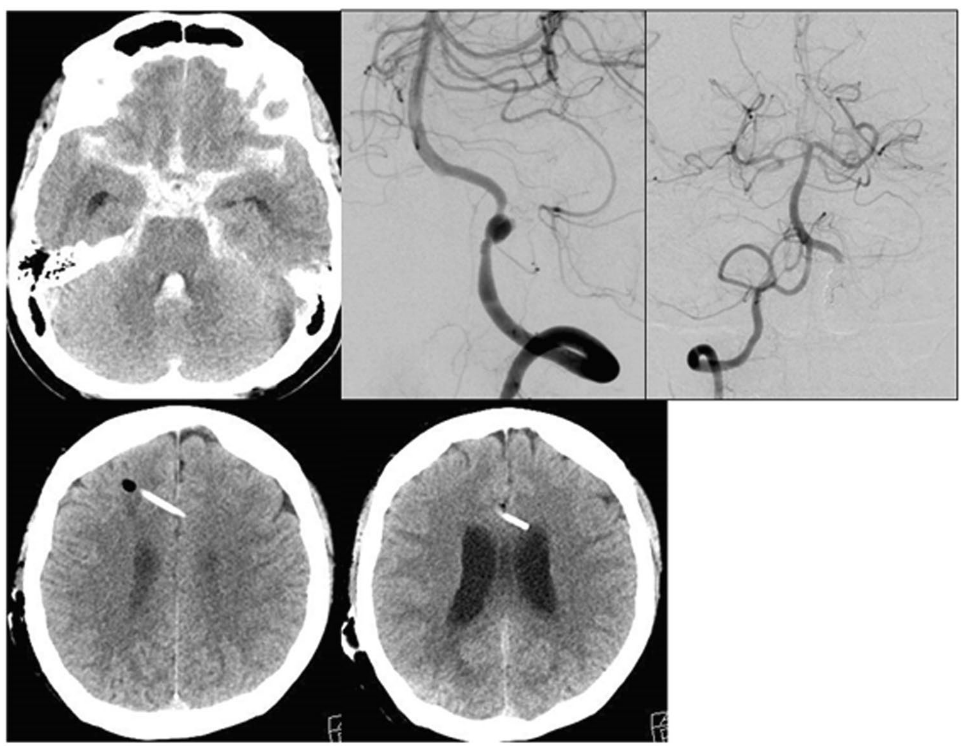

Fig. 2 Illustrated case of a technical morbidity event. We performed endovascular internal trap in a patient with subarachnoid hemorrhage due to left vertebral artery dissection aneurysm rupture. Two weeks later, we performed ventriculoperitoneal shunt for hydrocephalus. The shunt tube of the ventricle side was mispositioned, and reoperation was required. This event was classified as a personal issue

associated with surgery or the patient's condition. Typical critical events include acute coronary syndrome, pulmonary embolism, pneumonia, and hemorrhagic complications caused by antiplatelet or anticoagulation therapy. An illustrative case of this type is presented in Fig. 3. Critical events accounted for 15.9% of preventable events. A total of 18 of 34 critical events (52.9%) were classified as personal performance issues, and the other 16 (47.1%) were classified as systemic issues.

Judgment errors

Judgment errors were a direct result of surgical decision-making, inaccurate assessment of the risk–benefit of a

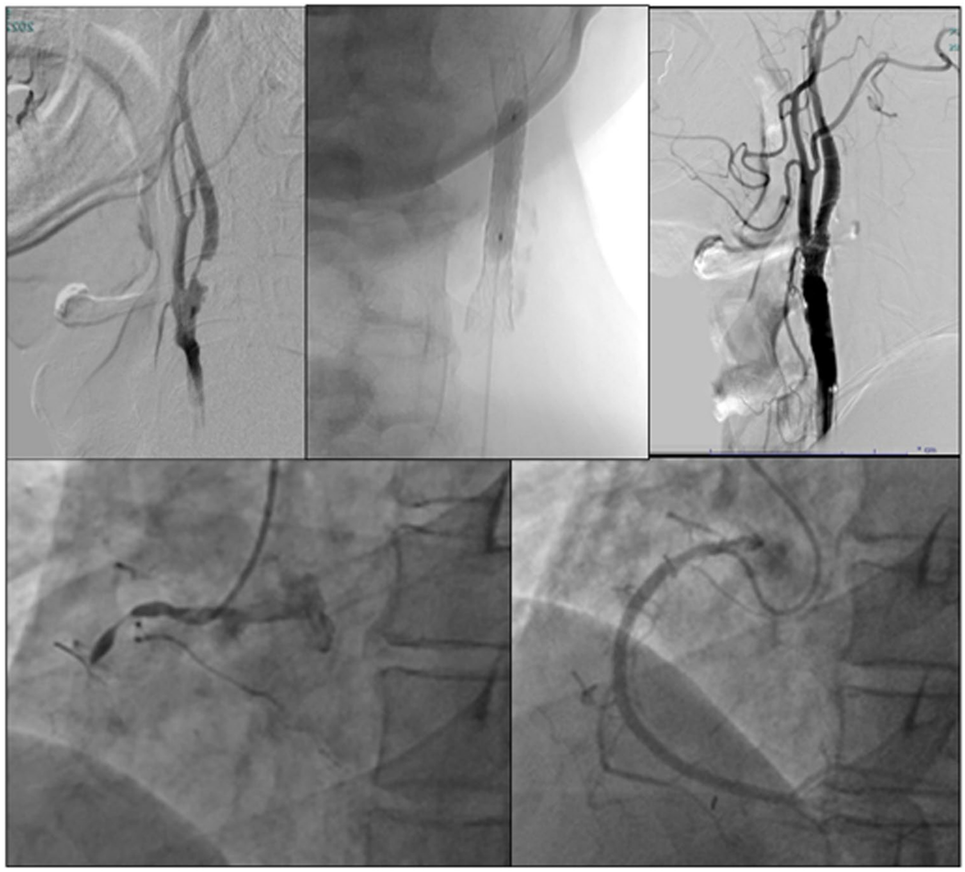

Fig. 3 Illustrated case of a critical event. We performed carotid artery stenting for asymptomatic carotid stenosis. Immediately after the procedure, the patient experienced chest pain, and an electrocardiogram change was detected. The right coronary artery was occluded and required percutaneous coronary intervention. This event was classified as a systemic issue. We subsequently created a system to detect asymptomatic coronary stenosis

disease, and patient selection. This type of error included patient selection error, inappropriate choice of treatment method, medical management error, misdiagnosis, and poor device selection. An illustrative case of this type is presented in Fig. 4. Judgment errors accounted for 6.1% of preventable events. A total of 11 of 13 judgment errors (84.6%) were classified as personal performance issues, and the other two events (15.4%) were classified as system issues.

Human factors

This category included human errors such as miscommunication, overlooked, omission, and misunderstanding. There were 12 human factor events (5.6%) during the study period, and errors of this category were the least frequent among the four categories. Four events (33.3%) were classified as personal performance issues, and the other eight (66.7%) were classified as systemic issues. The results of first step and second step are presented in Fig. 5.

Of the 214 preventable events, 179 events (83.6%) were classified as personal performance issues, and 35 events (16.4%) were classified as systemic issues. The ratio of personal performance to systemic issues varied widely, with significant differences among the four categories ($P < 0.01$) (Fig. 6).

Discussion

The main finding of this study was that preventable morbidity and mortality events in neurosurgery were mostly related to personal performance issues (83.6%), which were more frequent than systemic issues (16.4%). An analysis of consecutive neurosurgical patients led us to propose the characterization of morbidity and mortality events in neurosurgery into four categories: technical, critical events, judgment errors, and human factors. The impact of personal performance and systemic problems on each category varied widely. Identifying risk factors for morbidity and mortality events, whether personal performance or systemic issues, constitutes a crucial step towards their prevention, an important goal of quality assurance.

The characteristics of each root cause of preventable adverse events

Technical complications include technical issues that highlight poor surgical techniques or lack of experience in surgical procedures. Technical events were the most frequent category in our study. This result suggests that neurosurgery is directly linked to morbidity and mortality. Brenna et al. reported that neurosurgical practice was

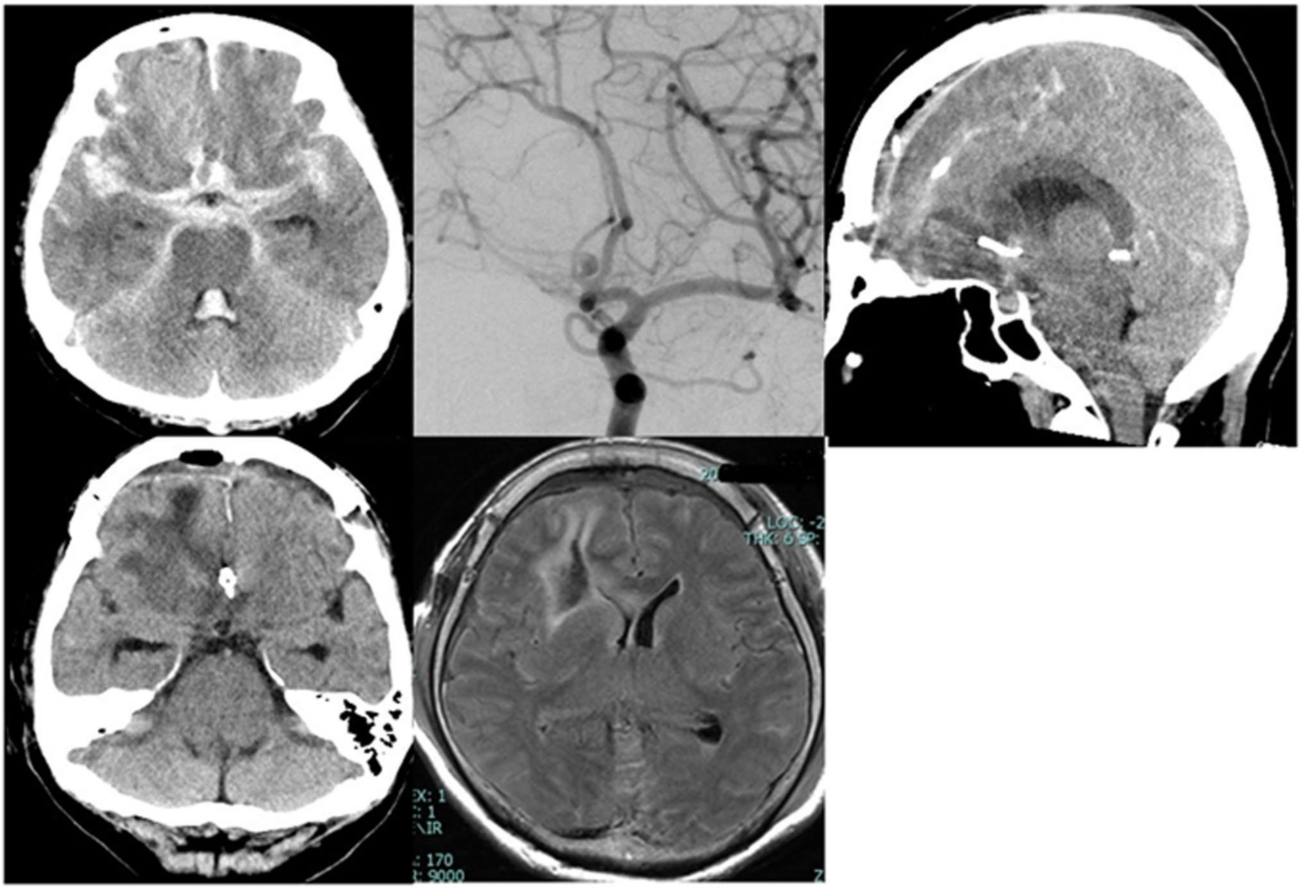

Fig. 4 Illustrated case of a judgment error. We performed aneurysm clipping and hematoma evacuation for subarachnoid hemorrhage with cerebral hemorrhage due to anterior communicating artery aneurysm rupture. Ventricle drainage was performed for 5 days. We removed the ventricle tube and inserted spinal drainage. The patient became comatose because of spinal drainage in spite of high intracranial pressure. This event was classified as a personal performance issue

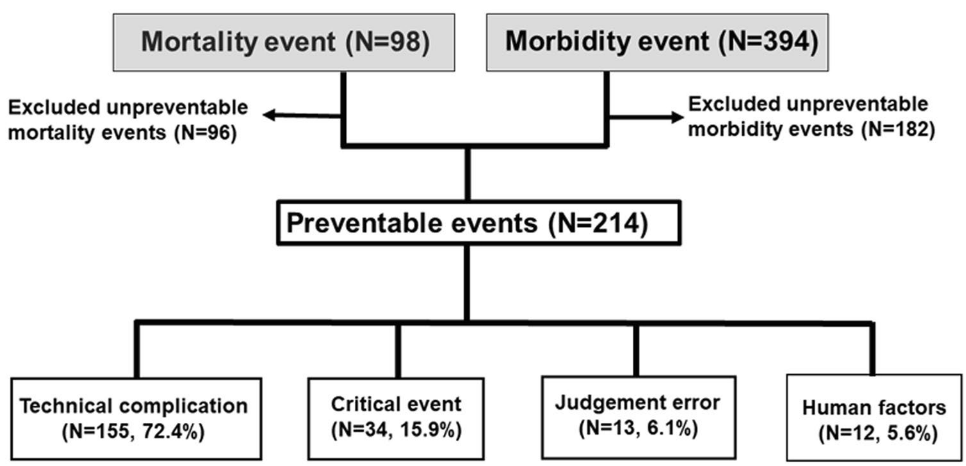

Fig. 5 Chart showing the result of morbidity and mortality event classification according to the first and second steps

associated with the highest proportion of adverse events among all surgical departments [1]. In their report, adverse events observed in neurosurgery accounted for 9.9% of all adverse events, which was greater than that observed in general surgery (7.0%), urology (4.9%), and orthopedics (4.1%) [1]. There is no doubt that systems can be created and developed. However, most of these complications are heavily associated with personal

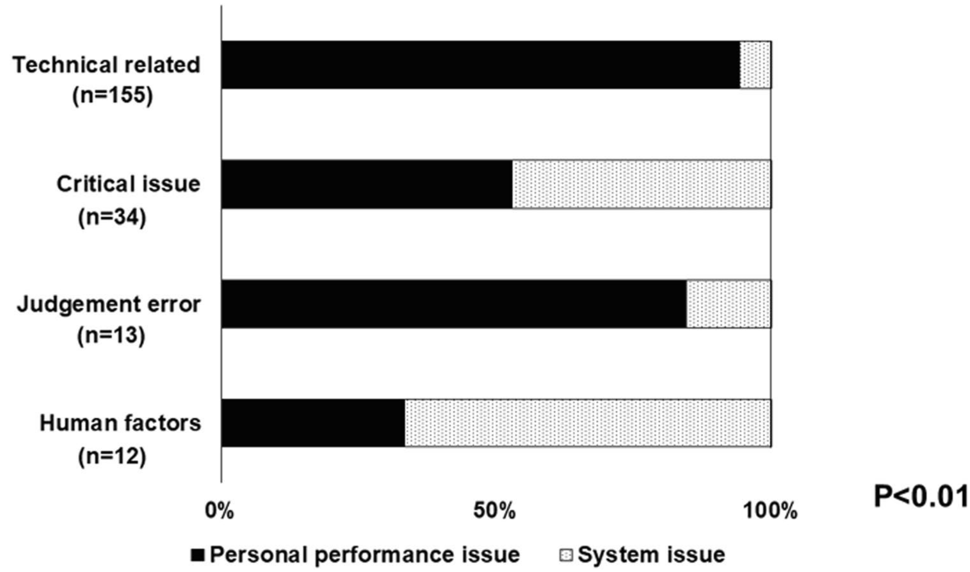

Fig. 6 Bar graph showing the ratio of personal and systemic issues among the four categories. The ratio of personal performance and systemic issues varied widely and showed significant difference among the four categories ($P < 0.01$)

performance and are not completely resolved by systemic development. System believer may think it difficult to avoid adverse event because of "to error is human." As other authors have pointed out [5, 15, 16], the excessive focus on system development may lead to abdication of personal responsibility by neurosurgeons. Therefore, personal efforts should be made to focus on interventions aimed at reducing these types of events. Of the four categories, the frequency of critical events may be decreased by the development of the preoperative examination system. Critical events may be unavoidable to a certain degree, but the frequency of these events must be tracked because deviations from rules may portend a system-based problem, such as inadequate preoperative examination. Therefore, among the four categories, critical events are the most frequently related to system problems.

Judgment errors are a direct result of surgical decision-making. These include improper patient selection, inaccurate assessment of the risk–benefit evaluation of a disease and procedure, poor treatment decisions, or equipment selection. Judgment errors may be difficult to recognize in the absence of an objective evaluation of decision-making and judgment processes. MMCs, which are considered to be a form of system development, can resolve this problem.

How to reduce preventable adverse events

The present results suggest that the ratio of personal and system issues for each root cause varies widely. Accordingly, the appropriate prevention method for adverse events may differ for those arising from personal and system issues.

Preventable morbidity and mortality events in neurosurgery were mostly related to personal performance issues, with nearly 70% of morbidity events related to surgical execution attributed to faulty equipment, poor experience, and lack of adequate training. Therefore, surgical training system development can reduce technical morbidity events to an extent. For example, a better hands-on training system to identify safety in neuro-endoscopy or endovascular surgery will decrease the number of injuries to adjacent normal structures. Therefore, appropriate system development may help to overcome a lack of personal performance.

Johna et al. suggested that although the discussion of error analysis as an aspect of personal failure is a potent stimulus for education, there is a strong belief that correction of adverse events should not be conducted through any assessment of blame or personal culpability [8]. Such opportunities enable learners to find the best measures in a friendly environment to avoid future errors and could play a major role in enhancing patient safety [8].

System deficits, rather than personal performance issues, are more prevalent in critical issues and human factors. It is likely that system issue–related events can be prevented by appropriate system development. Critical events may be preventable through the creation of a pre-operative examination system according to pathological condition (i.e., coronary artery examination for carotid stenosis [11, 12] or ultrasonographic diagnosis of venous thromboembolism in the lower limbs for patients with hemiplegia [13]). The typical preventable event-related system issue in human factors was communication errors. Taylor et al. suggested time-outs and checklists can reduce adverse events related to communication error during procedures. Careful differential diagnosis, attention to all relevant clinical information, and good communication are some factors under control of the surgeon that may reduce adverse events [14].

Limitations

This study had several limitations. First, it was a single-center study with a relatively small sample size. Therefore, a multicenter study with a larger number of morbidities is warranted. Another limitation is patient factors. We did not analyze the demographics, disease severity, or other preoperative factors. As older adults are at a high risk for critical events, the ratio of events in each category may differ between urban and rural areas. In further studies, general risk factors should be analyzed.

Conclusion

In neurosurgery, patients who have preventable morbidity events, issues related to personal performance, such as technical issues or judgment errors, are more frequent than systemic issues. Efforts to improve systems should be unwavering. However, the personal responsibility of neurosurgeons to avoid preventable complications should not be ignored.

Declarations

Ethics approval This study was approved by the Institutional Review Board of our institution. Informed consent was obtained from patients using the opt-out method on our institutional website. In accordance with the ethical standards of the institutional research committees, this non-invasive study did not require formal consent. Instead, the outline of the study was open to the public on our institutional homepage and provided an option for patients and their guardians to decline inclusion in the research.

Conflict of interest The authors declare no competing interests.

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