ORIGINAL ARTICLE

Perioperative Death within 24 Hours: An Analysis of 2,000 Incident Reports of the Perioperative and Anesthetic Adverse Events in Thailand (PAAd Thai) Study

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Background: Perioperative death is one of the indicators of anesthetic patient safety. The perioperative death rate has dramatically declined with the modern anesthetic techniques and perioperative medicine.

Objective: To study contributing factors, factors minimizing incidents, and suggested corrective strategies.

Materials and Methods: The present study was part of the Perioperative and Anesthetic Adverse Events in Thailand (PAAd Thai) Study, focusing on the incidents of perioperative death within 24 hours. The perioperative incidents from 22 tertiary hospitals across Thailand were gathered monthly. Two senior anesthesiologists reviewed the reports. Any discrepancy was solved by discussion for a consensus.

Results: Of the first 2,000 incident reports in the PAAd Thai Study, there were 404 (20.2%) incident reports of 24 hours perioperative death. Extreme age of less than one year in 6.2% and more than 80 years in 8.2%, with ASA physical status of 3 or more in 97% while 51.2% occurred in the age group between 20 to 64 years. General anesthesia was the main anesthetic technique among fatal cases in 94.1% of the cases. Ninety-one cases (22.5%) occurred in the operating theatre with anesthesiology team witness. The high-risk surgeries with fatal outcomes were general surgery in 46.2%, cardiac surgery in 12.5%, neurological surgery in 11.6%, and endoscopic procedure in 3.2%. Exsanguination in 52.7%, particularly after traffic accident was the major cause of death followed by cardiac factors in 27.2%, and sepsis in 23%. Intraoperative death had higher proportion of exsanguination at 72.5% than postoperative death at 43% (p<0.001). Postoperative death had higher proportion of sepsis-related death and brain death than intraoperative death at 27.5% versus 7.7% (p<0.001), and 20.8% versus 5.5% (p=0.001), respectively. The factor-related death included Patient in 97.8%, Surgical in 42.3%, Anesthetic in 19.3%, and Systematic factors in 31.4%. Fatal causes were considered as preventable in 28.7%, particularly by surgical safety checklist in 18.1%.

Conclusion: The multicenter study revealed a high proportion of 24 hours. perioperative death was commonly caused by exsanguination. Postoperative death was related to patient condition. Suggested corrective strategies were quality assurance activity, improved supervision, additional training, ICU availability, and more guidelines and compliance to guidelines including surgical safety checklists.

Keywords: Mortality; Perioperative death; Incident report; Surgical safety checklists; Adverse event; Incident report

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As patient safety is the first priority of anesthesiologists worldwide, various indicators of perioperative quality and safety have been established[1,2]. Perioperative death is one of the most focused outcomes. With development of modern anesthetic techniques and perioperative medicine, the perioperative death rate has dramatically declined from decade to decade[3-7]. However, preventable deaths are currently existing.

The World Health Organization (WHO) has endorsed the implementation of surgical safety checklists[8], which aims to improve not only the

quality but also the safety of performing surgical operations given the complexity of surgical operations and the patient conditions during perioperative periods. Nevertheless, the ineffectiveness of the surgical safety checklists to prevent possible adverse outcomes have been stated[9].

From the prior initiation of the nationwide safety research campaign of the Royal College of Anesthesiologists of Thailand (RCAT), the safety monitoring reports [Thai Anesthesia Incidents Study (THAI Study 2005) and the Thai Anesthesia Incident Monitoring Study (Thai AIMS 2007)] were published[10-13]. The RCAT subsequently held the Perioperative and Anesthetic Adverse Events in Thailand (PAAd Thai) Study[2,3] including the incident reports of 24 hours perioperative death. The aims of the present study were to describe the incidents of perioperative deaths, explore contributing factors and factors minimizing perioperative deaths and suggestive prevention strategies. In addition, the effectiveness of WHO surgical safety checklists were also monitored in the context of both anesthetic and surgical settings.

Materials and Methods

The present study was a prospective multi-centered study, as part of the Perioperative and Anesthetic Adverse Events in Thailand (PAAd Thai) Study, hosted by the RCAT between January and December 2015. All anesthesiologists and nurse anesthetists in 22 hospitals across Thailand that participated were asked to report critical incidents anonymously and voluntarily.

The specific anesthesia related adverse events detected during anesthesia and during 24 hours of postoperative period were reported by filling in a standardized incident reporting forms after encountering any adverse or undesirable events. The anesthesia profiles, surgical profiles, and narrative description of incidents were also recorded. Details of the present study methodology were previously described[2,3].

All incident recording forms, and monthly reports of anesthesia data were verified by each site manager. All of the collected information was sent to the data management unit at the Faculty of Medicine, Chulalongkorn University. Each incident report of the first 2,000 incidents was then reviewed by a group of data reviewers. The incident of death within 24 hours of perioperative period had been extracted and reviewed. All incident reports were separately reviewed by two expert anesthesiologists and subsequently made a consensus of the systematic analysis for contributing factors-related to mortality, corrective strategy, and the possibility of preventive ability by the WHO surgical safety checklists. The types of death-related factors were analyzed as surgical-related factors, patient condition-related factors, and anesthetic-related factors. The type of errors was described as preventable errors or inevitable errors with subsequent analysis of the cause of errors by way of knowledge-based errors, skill-based errors, or system-based errors.

The present study was approved by each institutional ethical committee with the exemption of the informed consent. The descriptive statistics were used to analyze data by using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). Chi-square test was used to compare proportions, while a p-value less than 0.05 was considered significant.

Results

Among the first 2,000 incident reports of the PAAd Thai Study, there were 404 cases (20.2%) of death within 24 hours. The mean age of the fatal cases within 24 hours was 48±24.3 years, while 219 cases (54.2%) were 20 to 64 years, 126 cases (31.2%) were 65 years or older, and 27 cases (8.7%) were younger than 10 years old (Figure 1). The majority of the cases, or 78.2%, were the American Society of Anesthesiologists (ASA) physical status of more than 3 (Figure 2). After data were analyzed by two independent reviewers, factors related death and types of errors considered are shown in Table 1. Regarding types of surgery based on surgical time frame as emergency versus non-emergency, 13.1% occurred during elective surgeries, whereas 86.9% during non-elective surgeries, which included non-trauma emergency in 52.2%, non-traffic trauma in 7.2%, and traffic accident in 27.2%. The majority of traffic accident-related death occurred in adult in 70.9% and adolescent in 11.8% of the patients. Exsanguination was the major causes of death in traffic at 80%, non-traffic trauma at 75.9%, and non-trauma emergency at 37.7%, whereas cardiovascular complications were the main causes of death in elective cases at 58.5%. High risk patients were the most common factor reported at 97.8%. Anesthetic factor was reported at 30.2% of elective mortality cases. There were higher proportions of male victims reported in trauma-related death, exsanguinated death, sepsis-related death, and brain death. Of note, up to 76.4% of trauma related exsanguination were male. On

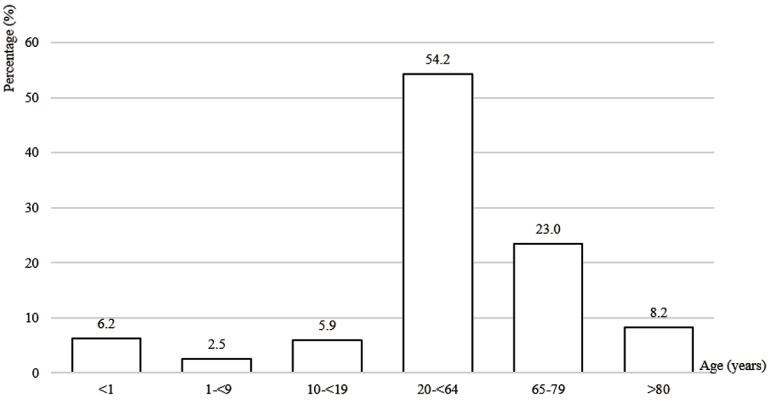

Figure 1. Age distribution of death within 24 hours (n=404).

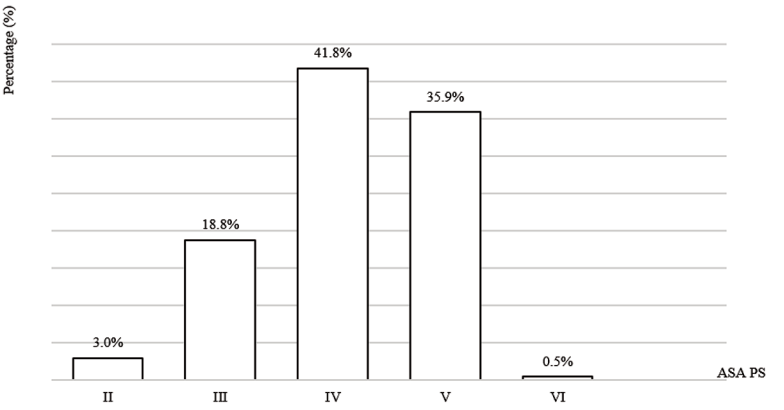

Figure 2. ASA physical status classification of death within 24 hours (n=404).

the other hand, there were higher female fatal cases reported in cardiovascular-related death and airway-related death for 49 of 93 cases (52.7%) and 12 of 20 cases (60%), respectively as shown in Table 2. In terms of anesthetic techniques, most of the cases had general anesthesia as the main anesthetic technique for 380 cases (94.1%). There were only 19 (4.7%) and 5 (1.2%) cases of monitor anesthetic care (MAC) and neuraxial block reported, respectively.

About half of the cases (50.5%), died in the intensive care unit (ICU) while 22.5% and 25% died in the operating room and ward, respectively. Regarding types of surgery based on subspecialty categories, general surgery was the highest reported death at 203 cases (46.2%) following by cardiac surgery in 55 cases (12.5%), neurological surgery in 51 cases (11.6%), thoracic surgery in 39 cases (8.9%), orthopedics surgery in 27 cases (6.2%), and vascular surgery in 22 cases (5%). There were 14 cases (3.2%) of death related to the endoscopic procedures. Exsanguination was considered as the main cause of death in 52.7% particularly in the cases with trauma while the other causes were cardiovascular cause in 23%, brain-death in 17%, and airway-related cause in 4.9%. Approximately one-fourth of deaths occurred intraoperatively with anesthesiology team witness for 91 of 404 cases (22.5%). Sixty-six of 91 (72.5%) of the deaths resulted from exsanguination. Intraoperative deaths had significantly higher proportion of exsanguination at 72.5% than post-operative death at 47% ($p<0.001$). In contrast, postoperative deaths either at ward or ICU had significantly higher proportion of sepsis-related death and brain death than intraoperative deaths at 27.5% versus 7.7% ($p<0.001$) and 20.8% versus 5.5% ($p=0.001$), respectively.

After review for core factors-related to the mortality in all 404 cases, patient-related factors, surgical-related factors, systematic-related factors, and anesthetic-related factors were considered in 97.8%, 42%, 31.4%, and 19%, respectively. The types of mortality-related to anesthesia were airway-related

Table 1. Patient characteristics, location of incidents, factors related to incidents, types of error classified by cause of perioperative death within 24 hours

		Causes of death							
	All cases	Exsanguination			Cardiovascular		Airway-related	Sepsis-related	Brain death
		Overall	Traffic	NTNC	Direct cardiac	Non-cardiac			
Number of patients; n (%)	404	213 (52.7)	110 (27.2)	83 (20.5)	93 (23.0)	52 (12.8)	20 (4.9)	93 (23.0)	70 (17.3)
Male:female	6.1:3.8	7.0:2.9	7.6:2.3	6.7:3.2	4.7:5.2	4.4:5.5	4:6	5.4:4.5	6.5:3.4
Age (years); mean±SD	48.0±24.3	47.1±22.2	38.8±19.1	57.7±20.4	46.3±30.5	58.7±26.4	39.4±24.6	54.6±23.3	44.2±21.6
Age group (years); n (%)									
<1	25 (6.2)	4 (1.9)	0 (0.0)	1 (1.2)	17 (18.3)	4 (7.7)	2 (10.0)	4 (4.3)	2 (2.9)
1 to 9	10 (2.5)	4 (1.9)	2 (1.8)	2 (2.4)	4 (4.3)	1 (1.9)	1 (5.0)	2 (2.2)	3 (4.3)
10 to 19	24 (5.9)	17 (8)	13 (11.8)	3 (3.6)	3 (3.2)	1 (1.9)	2 (10.0)	4 (4.3)	5 (7.1)
20 to 64	219 (54.2)	125 (58.7)	78 (70.9)	39 (47.0)	32 (34.4)	17 (32.7)	13 (65.0)	49 (52.7)	47 (67.1)
65 to 79	93 (23.0)	52 (24.4)	15 (13.6)	30 (36.1)	25 (26.9)	17 (32.7)	1 (5.0)	22 (23.7)	11 (15.7)
>80	33 (8.2)	11 (5.2)	2 (1.8)	8 (9.6)	12 (12.9)	12 (23.1)	1 (5.0)	12 (12.9)	2 (2.9)
ASA-PS; n (%)									
II	12 (3.0)	6 (2.8)	2 (1.8)	4 (4.8)	2 (2.2)	2 (3.8)	1 (5.0)	3 (3.2)	1 (1.4)
III	76 (18.8)	30 (14.1)	3 (2.7)	20 (24.1)	27 (29.0)	18 (34.6)	7 (35.0)	15 (16.1)	12 (17.1)
IV	169 (41.8)	73 (34.3)	31 (28.2)	34 (41.0)	38 (40.9)	22 (42.3)	8 (40.0)	54 (58.1)	32 (54.7)
V	145 (35.9)	103 (48.4)	74 (67.3)	25 (30.1)	26 (28.0)	10 (19.2)	4 (20.0)	20 (21.5)	25 (35.7)
VI	2 (0.5)	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0v)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)
Death scene; n (%)									
OR	91 (22.5)	67 (31.5)	32 (29.1)	24 (28.9)	25 (26.9)	11 (21.2)	5 (25.0)	7 (7.5)	5 (7.1)
ICU	204 (50.5)	112 (52.6)	62 (56.4)	41 (49.4)	54 (58.1)	30 (57.7)	10 (50.0)	48 (51.6)	29 (41.4)
Ward	101 (25.0)	30 (14.1)	15 (13.6)	15 (18.1)	12 (12.9)	9 (17.3)	4 (20.0)	36 (38.7)	35 (50.0)
Factor-related death; n (%)									
Patient factor	395 (97.8)	206 (96.7)	110 (100)	77 (92.8)	92 (98.9)	52 (100)	19 (95)	93 (100)	69 (98.6)
Surgical factor	171 (42.3)	130 (61.0)	52 (47.3)	59 (71.1)	45 (48.4)	17 (32.7)	10 (50)	16 (17.2)	11 (15.7)
Anesthetic factor	78 (19.3)	35 (16.4)	12 (10.9)	19 (22.9)	18 (19.4)	14 (26.9)	9 (45.0)	28 (30.1)	6 (8.6)
Systematic factor	127 (31.4)	46 (21.6)	23 (20.9)	22 (26.5)	17 (18.3)	14 (26.9)	11 (55.0)	47 (50.5)	32 (45.7)
Corrective strategy; n (%)									
Preventable case	116 (28.7)	46 (21.6)	5 (4.5)	27 (32.5)	39 (41.9)	22 (42.3)	7 (35.0)	39 (41.9)	10 (14.3)
SSC preventive role	73 (18.1)	22 (10.3)	4 (3.6)	13 (15.7)	21 (22.6)	16 (30.8)	7 (35.5)	33 (35.5)	8 (11.4)
Cause of errors; n (%)									
System based error	52 (12.9)	15 (7.0)	3 (2.7)	12 (14.5)	14 (15.1)	12 (25)	8 (40.0)	25 (26.9)	4 (5.7)
Knowledge based error	70 (17.3)	22 (10.3)	2 (1.8)	15 (18.1)	23 (24.7)	15 (28.8)	7 (35.0)	30 (32.3)	5 (7.1)
Skill based error	54 (13.4)	26 (12.2)	1 (0.9)	14 (16.9)	20 (21.5)	7 (13.5)	4 (20.0)	16 (17.2)	1 (1.4)

Values are not mutually exclusive

NTNC=non-trauma - non-cardiac; ASA-PS=American Society of Anesthesiologists physical status; OR=operating room; ICU=intensive care unit; SSC=surgical safety checklists; SD=standard deviation

cause in 45% and sepsis in 30.1%. Regarding the cause of errors, knowledge-based error was detected in 17.3% followed by skill-based error and system-based error at 13.4% and 12.9%, respectively. The characteristics of mortality cases characterized by causes of deaths are also shown in Table 1.

Overall preventable cases were considered in 28.7% and surgical safety checklist preventable cases were considered in 18.1%. Moreover, those with elective cases, preventable cases were recognized in 60.4% whereas surgical safety checklist preventable cases were detected in 34%. The characteristics of mortality cases categorized by types of cases are also shown in Table 2.

Considering the model of anesthesia, contributing factors related to mortality were emergency in 85.4% and haste in 20.9% of the situations. Human error factors were related to inadequate preoperative evaluation in 34.7%, inexperience in 32.7%, inappropriate decision making in 32.4%, and

Table 2. Patient characteristics, location of incidents, factors related to incidents, causes of death, and types of error classified by emergency and elective conditions

	All cases	Traffic trauma	Non-traffic trauma	Non-trauma emergency	Elective
Number of patients; n (%)	404	110 (27.2)	29 (7.2)	212 (52.5)	53 (13.1)
Male:female	6.1:3.8	7.3:2.6	7.5:2.4	5.7:4.2	4.7:5.2
Age (years); mean±SD	48.0±24.3	38±19.3	49.2±21.5	53.7±23.0	43.9±32.5
Age group (years); n (%)					
<1	25 (6.2)	0 (0.0)	0 (0.0)	12 (5.7)	13 (24.5)
1 to 9	10 (2.5)	2 (1.8)	0 (0.0)	5 (2.4)	3 (5.7)
10 to 19	24 (5.9)	13 (11.8)	2 (6.9)	7 (3.3)	2 (3.8)
20 to 64	219 (54.2)	78 (70.9)	20 (69)	106 (50.0)	15 (28.3)
65 to 79	93 (23.0)	13 (11.8)	4 (13.8)	63 (29.7)	13 (24.5)
>80	33 (8.2)	4 (3.6)	3 (10.3)	13 (6.1)	7 (13.2)
ASA-PS; n (%)					
II	12 (3.0)	0 (0.0)	2 (6.9)	3 (1.4)	7 (13.2)
III	76 (18.8)	10 (9.1)	4 (13.8)	36 (17.0)	26 (49.1)
IV	169 (41.8)	33 (30)	7 (24.1)	112 (52.8)	17 (32.1)
V	145 (35.9)	67 (60.9)	16 (55.2)	59 (27.8)	3 (5.7)
VI	2 (0.5)	0 (0.0)	0 (0.0)	2 (0.9)	0 (0.0)
Death scene; n (%)					
OR	91 (22.5)	26 (23.36)	9 (31.0)	44 (20.8)	12 (22.6)
ICU	204 (50.5)	61 (55.5)	14 (48.3)	99 (46.7)	30 (56.6)
Ward	101 (25.0)	22 (20.0)	5 (17.2)	64 (30.2)	10 (18.9)
Causes of death; n (%)					
Exsanguination	213 (52.7)	88 (80.0)	22 (75.9)	80 (37.7)	23 (43.4)
Direct cardiac	93 (23.0)	3 (2.7)	5 (17.2)	54 (25.5)	31 (58.5)
Airway-related	20 (4.9)	3 (2.7)	0 (0.0)	12 (5.7)	5 (9.4)
Sepsis-related	93 (23.0)	4 (3.6)	0 (0.0)	85 (40.1)	4 (7.5)
Brain death	70 (17.3)	38 (34.5)	4 (13.8)	25 (11.8)	3 (5.7)
Factor-related death; n (%)					
Patient factor	395 (97.8)	110 (100)	29 (100)	208 (98.1)	53 (100)
Surgical factor	171 (42.3)	46 (41.8)	10 (34.5)	82 (38.7)	33 (62.3)
Anesthetic factor	78 (19.3)	7 (6.4)	7 (24.1)	48 (22.6)	16 (30.2)
Systematic factor	127 (31.4)	28 (25.5)	7 (24.1)	79 (37.3)	13 (24.5)
Corrective strategy; n (%)					
Preventable cases	116 (28.7)	6 (5.5)	7 (24.1)	71 (33.5)	32 (60.4)
SSC preventive role	73 (18.1)	5 (4.5)	5 (17.2)	45 (21.2)	18 (34.0)
Cause of errors; n (%)					
System based error	52 (12.9)	4 (3.6)	4 (13.8)	32 (15.1)	12 (22.6)
Knowledge based error	70 (17.3)	2 (1.8)	5 (17.2)	47 (22.2)	16 (30.2)
Skill based error	54 (13.4)	1 (0.9)	1 (3.4)	31 (14.6)	21 (39.6)

Values are not mutually exclusive

ASA-PS=American Society of Anesthesiologists physical status; OR=operating room; ICU=intensive care unit; SSC=surgical safety checklists; SD=standard deviation

insufficient knowledge in 22%. Suggested corrective strategies were quality assurance activity, morbidity and mortality conference in 82.4%, improvement of supervision in 40.3%, guidelines in 27.5%, additional training in 24.8%, availability of ICU bed in 22.8%, and more workforce in 15.2%. The results of analyses of contributing factors related to mortality and suggested corrective strategies are shown in Figure 3.

Discussion

The present multicenter national quantitative anesthetic database (PAAd Thai Study), revealed

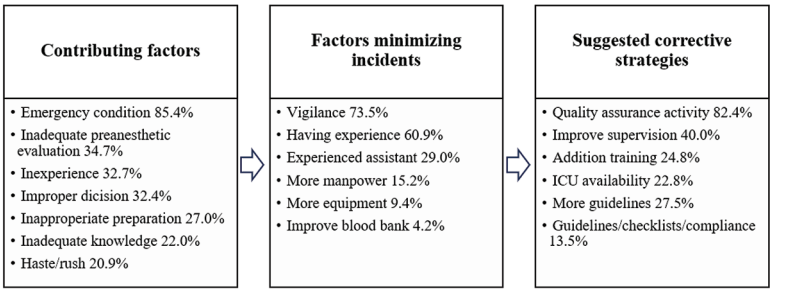

Figure 3. Model of anesthesia related 24 hours perioperative death.

that postoperative deaths occurred as high as 20.2% of 2,000 adverse events. Exsanguination was the most common causes of deaths. Patients' conditions were considered as factor-related death up to 97.8%, whereas anesthetic factors were considered as a cause in 19.3%. Preventable death cases were recognized at 28.7%. Of note, 18.1% of death cases could be avoidable by using the surgical safety checklists.

The perioperative death within 24 hours was the main outcome in the present study. As mentioned earlier, of the first 2,000 cases of the PAAd Thai Study[1,2], 404 deaths or 20.5% were analyzed in the present study. These findings could reflect the concern of perioperative adverse events and the safety and quality improvement in Thailand. When comparing to the previous nation-wide study conducted in 2005 (THAI study), the incidences of perioperative cardiac arrest and death dramatically declined. The incidence of perioperative cardiac arrest decreased from 30.8 per 10,000 anesthesia[3] to 15.5 per 10,000 anesthesia[2] while the incidence of death decreased from 28.2 per 10,000 anesthesia[3] to 13.2 per 10,000 anesthesia[2]. From a global perspective, the perioperative mortality incidents were reported as 2.36 to 34.6 per 10,000 anesthetics[5-7,14,15]. The present report demonstrated the improvement in safety system of surgery in Thailand, however, there is room to improve the developed countries' level of perioperative safety[7,16-18].

The present data found that age relate to the cause of death. Causes of death among younger ages included trauma-related exsanguination and airway-related death. The average age of death cases in traffic trauma-related exsanguination was 38.8±19.1 years. As expected for trauma-related exsanguination, teenagers and young adults are the high-risk groups to the traffic-related exsanguination death. A previous study found that trauma-related death mostly linked to working age group and the socioeconomics[19]. Lee et al.[20] reported the critical incident of pediatric surgery with the highest reports of airway-related adverse events. Meanwhile, Bhananker et al.[21] pinpointed that hypovolemia and airway obstruction were the leading causes of cardiac arrest in pediatrics at 79 of 193 (41%) and 52 of 193 (27%), respectively and mortality after cardiac arrest was 28%, predicted by ASA-physical status and emergency situation. On the contrary, the present study highlighted the death in neonatal and infant were mainly related to congenital heart surgery and airway events while children and young adults' cause of death was trauma-related exsanguination.

Among fatal cases of the elderly, the majority of causes of death were cardiovascular-related deaths in non-cardiac surgery, non-trauma-non-cardiac exsanguination, and sepsis-related deaths. According to the previous incident reports study (Thai AIMS)[3], the proportion of the elderly, in the age group of older than 65 years, was 22.0%, whereas the incident of adverse events and death within 24 hours was 4.9%. As up to one third of the death cases in the present study were elderly patients, this result may indicate the growing of aging society in Thailand.

Regarding gender, the authors reported high ratio of male to female cases of 6.1 to 3.8. The PAAd Thai Study also reported higher ratio of adverse events on male at 5.2 to 4.8, which was higher than THAI study at 4.7 to 5.3[3,11]. Moreover, ratio of male cases was extremely high in both traffic trauma and non-traffic trauma at 7.3 to 2.6 and 7.5 to 2.4, respectively. The high ratio of male to female trauma cases were reported in studies world-wide[22-25]. Interestingly, the only initial event with higher female cases was male to female ratio in elective surgery at 4.7 to 5.2. In addition, airway-related, cardiovascular cause had higher proportion of female in the present study.

Regarding the causes of death, half of the death cases (52.5%) were presented as non-trauma emergency case with high proportion of advanced age and sepsis. In the present study, the sepsis-related

death group had the second highest average age, which could increase the risk of septic shock death as shown in the previous study[17]. From National Surgical Quality Improvement Program (NSQIP) database[17], emergency operation and sepsis predict 5.3- and 3.5-times higher risk of perioperative death after major surgery. Sepsis-related death has been reported to be decreased in this era[26-29]. However, there were different definitions and stratification of patients with sepsis that need to be defined. Based on the present study data, the authors found an increasing trend toward sepsis- related deaths. The operations with higher rate of sepsis-related deaths included urological surgery at 50%, general surgery at 33.9%, and vascular surgery at 13.6%. Therefore, the authors would suggest identifying high risk patients of sepsis along with sepsis risk reduction protocol that would improve the outcomes.

From the present study report, road traffic death is one of the leading events. The finding corresponded to the WHO report that Thailand was second in road traffic death at 36.6 per 1,000,000 population per year[18]. Unfortunately, even with a high level of care, extremely cautious trauma teams, and a great supporting system, the victims might not be able to be rescued because of the highest severity of the injury indicated by ASA 5 of 60.9%. Therefore, there was only 5.5% of preventable cases and 4.5% of possible preventable role of surgical safety checklists among this group of patients. The authors' suggestion on the road traffic death is that the government should increase road safety policy by enforcing the speed limit, prohibiting psychoactive substances, promoting motorcycle helmets usage, child restraints law, reduction of distracted driving, unsafe road infrastructure, and unsafe vehicles along with the development of the emergency care system for trauma victims.

The worldwide incidence of perioperative major cardiac events following non-cardiac surgery was reported around 2% to 3%[30-32]. Although the revised cardiac risk index for pre-operative risk was relevant and followed in routine practice, the urgency of the operations and possibility of inadequate perioperative preparation and investigation for definite cardiac condition diagnosis might be the main reasons contributed to cardiovascular-related deaths[33].

There has been a decreasing trend in global airway-related morbidity and mortality incidence secondary to the thoroughly availability of the pulse oximeters and airway management devices including video laryngoscopes and the modern breathing systems[34]. Nevertheless, while the incidences of difficult intubation and failed intubation dramatically decreased in Thailand from 22.5 per 10,000 to 8 per 10,000[3,11], the airway-related death was reported as 4.9% in the present study[35]. Notably, the authors' airway-related fatal cases directly contributed to anesthesia practice as indicated by the prominent anesthetic factor up to 40% related to the death. Additional training and supervision were the suggested factors minimizing incidence and corrective strategies. The authors would propose the prompt availability of the anesthetic equipment with well-trained personnel for crisis airway management to lessen the airway-related death cases.

According to systemic errors, 50.5% of the death cases occurred in the ICU. The ICU availability in terms of increased ICU beds, adequate equipment, well-trained personnel, and proper critical care management have been suggested as one of the corrective strategies in the model of the present study.

Modern and minimal invasive surgery has less effect on physiologic change postoperatively and resulted in improving the outcomes[36,37]. However, the highest vigilance must be taken perioperatively especially in high-risk patients including those with elderly and comorbidities. The present study data suggested that perioperative risk reduction with careful monitoring would decrease the mortality incidence in accommodating with the team awareness by using the surgical safety checklists guideline[38-40].

In a university hospital in Thailand, the overall incidences of intraoperative and 24-hour perioperative cardiac arrest were reported to be 10 and 21 per 10,000 anesthesia while anesthesia related mortality was only 0.198 per 10,000 anesthetics[35]. This indicated that effective perioperative cardiopulmonary resuscitation should be encouraged and maintained in the clinical practice guideline.

In the present study, the authors evaluated the potential preventable role of the surgical safety checklist by a committee of experts. The surgical safety checklists showed that 18.1% of all incidents were preventable. Moreover, among preventable death cases, the surgical safety checklists had its possible preventive role up to two-thirds of them. However, of the inevitable situations, there were only two out of 388 cases reported as possible preventable using the surgical safety checklists from the expert opinion. Additionally, the surgical safety checklists seemed to have a higher role in rule- based, knowledge-based, and system-based errors. There was only 30% of the skill-based error reported as

possible preventable by the surgical safety checklists.

The present study interestingly found that the most common corrective strategy was a quality assurance conference, thus a morbidity and mortality conference. Even in the inevitable cases, there were learning points that should be reviewed, and analyzed for developing preventive strategy, especially in trauma cases. Moreover, improvement of supervision, proper guideline development, and additional training were strongly suggested. More availability of ICU beds and more manpower have been mentioned in 15.2%.

There were limitations of the present study. First, the PAAd Thai Study was not a randomized control study with retrospective analysis of incident reports collected in prospective manner. Second, there were definitions of mortality used in different studies such as within 24 hours, within 48 hours, or 7 days after surgery. However, the authors considered choosing death within 24 hours, which was the strong indicator usually reported in each institution. Third, it was difficult for reviewers to accurately consider the causes, factors related to death within 24 hours. However, the present study was able to reveal trend or proportion of contributing causes and suggested strategies for improvement for the policymaker.

In conclusion, this large multicenter national quantitative anesthetic database (PAAd Thai Study) revealed a high proportion of 24 hours perioperative deaths, which mostly was commonly contributed by exsanguination. Postoperative death was mainly related to patient condition. Based on the present study, the authors would like to emphasis on the necessary of following the surgical safety checklists and regularly attending quality assurance conferences for root cause analysis to decrease the preventable perioperative mortality.

What is already known on this topic?

The incidences of perioperative cardiac arrest decreased from 30.8:10,000 to 15.5:10,000 anesthetics, while 24-hour perioperative death decreased from 28.2:10,000 to 13.2:10,000 anesthetics in Thailand. While global incidence of perioperative mortality with different definitions varied between 2.36 to 34.6 per 10,000 anesthetics.

What does this study add?

Twenty-four hours perioperative death in Thailand occurred commonly in patients with extreme age of less than one year or more than 80 years, and ASA physical status of 3 or higher. High risk surgeries were general, cardiac, and neurological surgery. Common causes of death were exsanguination, particularly after traffic accident, cardiac cause, and sepsis related causes. Patient factor was considered as cause of most fatal cases, while one-fifth was considered as anesthesia related. Suggested preventive strategies were quality assurance activity, improvement of supervision, additional training, compliance to guidelines including surgical safety checklists, as well as The Ongoing Professional Practice Evaluation (OPPE) and Focused Professional Practice Evaluation (FPPE) in Joint Commission International standards to evaluate and act upon concerns regarding a privileged anesthesia's practice and competency assessment and increase ICU availability.

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Conflicts of interest

The authors declare no conflict of interest.

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