

Evaluation of Surgical Complications in a University Hospital: A Novel Root Cause Analysis Classification

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Objective: To analyze general surgery morbidity and mortality in King Chulalongkorn Memorial Hospital to identify the preventability and root causes of the complications using a novel root cause analysis (RCA) classification according to the period that the corrective action could have been introduced to prevent the complications.

Materials and Methods: The authors retrospectively reviewed the morbidity and mortality between October 2012 and October 2016. The data collection included diagnostic groups, organ systems, severity, preventability, and RCA of the complications. Functional outcomes of the patients were also obtained such as full recovery, residual functional impairment, and death.

Results: Six hundred seventy-six surgical complications occurred out of 19,440 surgeries performed (3.47%) during the study period. The most common organ system involved was gastrointestinal system (42.8%), followed by wound complications (18.9%). According to the Clavien-Dindo classification, the severity of the complications was 20.7% as grade 1, 18.9% as grade 2, 41.6% as grade 3, 3.7% as grade 4, and 15.1% as grade 5. The authors classified 27 complications as preventable (4.0%), 573 as potentially preventable (84.8%), and 76 as unpreventable (11.2%). RCA of the preventable and potentially preventable complications using the present RCA classification revealed that root causes were defect in the diagnoses (0.5%), defect in management decision making (5.0%), defect in preoperative management (6.1%), defect in intraoperative management (61.3%), and defect in postoperative management (27.0%). The most common defect in intraoperative management was inappropriate surgical approach or technique (58.7%). Most patients (80.2%) fully recovered from the complications, while 4.7% had residual functional impairment, and 15.1% died.

Conclusion: The present study demonstrated that most complications in general surgery were preventable or potentially preventable. RCA showed that the most common root cause was the defect is intraoperative management, especially inappropriate surgical approach or technique.

Keywords: Surgical complications; Root cause analysis; Morbidity and mortality conference

Received 27 March 2019 | Revised 2 February 2021 | Accepted 3 February 2021

J Med Assoc Thai 2021;104(4):522-6

Website: <http://www.jmatonline.com>

Surgery, like other methods of treatment, can result in negative outcomes. Surgical complications are defined as “any deviation from the normal or ideal postoperative course”. Surgical complications should be differentiated from “sequelae” or inevitable conditions inherent in the procedure, and “failure to cure”^(1,2). In 2004, Dindo et al proposed a classification for surgical complications, validated by

an international survey, which helped in evaluation and comparison of surgical outcomes among institutions (Table 1)^(3,4). However, the Clavien-Dindo classification focuses mainly on outcomes of the complications without considering the root causes and the preventability of the complications. In the present study, the authors analyzed general surgery morbidity and mortality in King Chulalongkorn Memorial Hospital to identify preventability and root causes of the complications using a novel root cause analysis (RCA) classification.

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How to cite this article:

Prichayudh S, Tungprayoonlert T, Sriussadaporn S, Pak-art R, Sriussadaporn S, Kritayakirana K, et al. Evaluation of Surgical Complications in a University Hospital: A Novel Root Cause Analysis Classification. J Med Assoc Thai 2021;104:522-6.

doi.org/10.35755/jmedassocthai.2021.04.10011

Materials and Methods

The authors retrospectively reviewed the general surgery morbidity and mortality data at King Chulalongkorn Memorial Hospital, a 1,400-bed university hospital and a level 1 trauma center in Bangkok, Thailand, between October 2012 and October 2016. The data collection included diagnostic groups, organ systems involved, details

Table 1. Classification of surgical complications (the Clavien-Dindo classification)⁽³⁾

Grade	Definition
I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiologic interventions Allowed therapeutic regimens are drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy This grade also includes wound infections opened at the bedside
II	Requiring pharmacological treatment with drugs other than such allowed for grade I complications Blood transfusions and total parenteral nutrition are also included
III	Requiring surgical, endoscopic, or radiological intervention
IIIa	Intervention not under general anesthesia
IIIb	Intervention under general anesthesia
IV	Life-threatening complication requiring intermediate care/intensive care unit management
IVa	Single organ dysfunction
IVb	Multiorgan dysfunction
V	Death of a patient
Suffix "d"	If the patient suffers from a complication at the time of discharge, the suffix "d" (for "disability") is added to the respective grade of complication This label indicates the need for a follow-up to fully evaluate the complication

of the complications, severity of the complications according to the Clavien-Dindo classification (Table 1), preventability, and RCA of the complications. The authors classified the general surgical patients into 7 diagnostic groups, i.e., hepatobiliary pancreas (HBP), gastrointestinal (GI), colorectal, vascular, endocrine, trauma, and miscellaneous that included breast, soft tissue, and abdominal wall. During the morbidity and mortality conference, the preventability of the complications was discussed and classified by the surgical department faculties, including all the authors, into 3 categories, i.e., preventable, potentially preventable, and unpreventable. Preventable complication was defined as a complication that could have been prevented with a proper corrective action. Potentially preventable complication was defined as a complication that could have been possibly prevented with a proper corrective action. Unpreventable complication was defined as a complication that could not have been prevented with any corrective action.

At the authors' institution, morbidity and mortality conferences were held every two weeks. All board-certified attending surgeons of the General Surgery Units were invited to discuss the causes, preventability, and RCA of each complication. Different opinions would be openly discussed among the faculties until a conclusion was reached and the results would finally be recorded by the first author.

For preventable and potentially preventable complications, the RCA would be performed by the surgical department faculties. With the authors' novel RCA classification, the root causes

of the complications were classified into five categories, depending on the period that the corrective action could have been introduced to prevent the complications as follows:

1. Defect in diagnosis (i.e., delayed diagnosis or missed diagnosis of the principal disease).
2. Defect in management decision making (i.e., making a wrong selection between non-operative and operative management, delayed surgery, and unnecessary operation).
3. Defect in preoperative management (i.e., failure to optimize patients' condition before surgery).
4. Defect in intraoperative management (i.e., inappropriate surgical approach or technique, breaks in sterile technique, and failure to provide a standard intraoperative care).
5. Defect in postoperative management (i.e., failure to provide a standard postoperative care, and failure to timely detect and treat a complication postoperatively).

According to the authors' RCA, one patient could have more than one root causes per one complication such as a deep surgical site infection may have resulted from a break in sterile technique and a delayed detection postoperatively. Functional outcomes of the patients were classified into full recovery, residual functional impairment, and death.

Results

Six hundred seventy-six complications occurred out of 19,440 surgeries performed (3.47%) during the study period with 4.0% preventable, 84.8%

Table 2. Diagnostic groups of the patients with complications stratified by preventability

Diagnosis group	Preventability; n (%)			Total
	Preventable	Potentially preventable	Unpreventable	
Hepatobiliary pancreas	8 (4.4)	156 (85.7)	18 (9.9)	182 (26.9)
Gastrointestinal	6 (4.2)	125 (86.8)	13 (9.0)	144 (21.3)
Colorectal	1 (0.9)	99 (93.4)	6 (5.7)	106 (15.7)
Endocrine	0 (0.0)	26 (100)	0 (0.0)	26 (3.8)
Trauma	4 (8.5)	24 (51.1)	19 (40.4)	47 (7.0)
Vascular	4 (5.0)	61 (76.3)	15 (18.8)	80 (11.8)
Miscellaneous	4 (4.4)	82 (90.1)	5 (5.5)	91 (13.5)
Total	27 (4.0)	573 (84.8)	76 (11.2)	676

Table 3. Organ systems involved by complications stratified by preventability

Organ systems	Preventability; n (%)			Total
	Preventable	Potentially preventable	Unpreventable	
Neurological	1 (4.8)	12 (57.1)	8 (38.1)	21 (3.1)
Respiratory	6 (7.7)	60 (76.9)	12 (15.4)	78 (11.5)
Cardiovascular	3 (3.9)	48 (63.2)	24 (31.6)	76 (11.2)
Gastrointestinal	10 (3.5)	262 (90.1)	17 (5.9)	289 (42.8)
Kidney/urinary	3 (12.0)	20 (80.0)	2 (8.0)	25 (3.7)
Wound	2 (1.6)	125 (97.7)	1 (0.8)	128 (18.9)
Other	2 (3.3)	46 (76.7)	12 (20.0)	60 (8.9)
Total	27 (4.0)	573 (84.8)	76 (11.2)	676

Table 4. Severity of the complications according to the Clavien-Dindo classification stratified by preventability

Severity	Preventability; n (%)			Total
	Preventable	Potentially preventable	Unpreventable	
Class I	7 (5.0)	130 (92.9)	3 (2.1)	140 (20.7)
Class II	1 (0.8)	118 (92.8)	9 (7.0)	128 (18.9)
Class IIIa	1 (0.8)	117 (95.1)	5 (4.1)	123 (18.2)
Class IIIb	9 (5.7)	145 (91.8)	4 (2.5)	158 (23.4)
Class Iva	1 (4.3)	18 (78.3)	4 (17.4)	23 (3.4)
Class IVb	0 (0.0)	2 (100)	0 (0.0)	2 (0.3)
Class V	8 (7.8)	43 (42.2)	51 (50.0)	102 (15.1)
Total	27 (4.0)	573 (84.8)	76 (11.2)	676

potentially preventable, and 11.2% unpreventable, as shown in Table 2. The most common diagnostic group was HBP (26.9%), followed by GI (21.3%) and Colorectal (15.7%). The most common organ system involved was GI system (42.8%), followed by wound complications (18.9%) as shown in Table 3. According to the Clavien-Dindo classification, most of the complications required surgical, endoscopic, or radiological intervention (grade III, 41.6%), while

3.7% resulted in organ dysfunction (grade IV) and 15.1% resulted in mortality (grade V) as shown in Table 4.

According to the present study of RCA classification, there were 734 root causes for the 600 preventable or potentially preventable surgical complications. RCA revealed that defect in intraoperative management was the most common root cause (61.3%), followed by defect

Table 5. Root cause analysis of the 600 preventable and potentially preventable complications

Root causes	Preventability; n (%)		
	Preventable	Potentially preventable	Total
Diagnosis	2 (50.0)	2 (50.0)	4 (0.5)
Management decision	6 (16.2)	31 (83.8)	37 (5.0)
Preoperative	1 (2.2)	44 (97.8)	45 (6.1)
Intraoperative	14 (3.1)	436 (96.9)	450 (61.3)
Postoperative	10 (5.1)	188 (94.9)	198 (27.0)
Total	33 (4.5)	701 (95.5)	734

Numbers in the table represent number of root causes (one complication could have more than one root causes)

in postoperative management (27.0%), and defect in preoperative management (6.1%) as shown in Table 5. Of the 450 complications with defect in intraoperative management, 264 (58.7%) were caused by inappropriate surgical approach or technique. The examples of inappropriate surgical approach or technique were choosing an improper operation, choosing an improper incision, inadequate exposure, improper anastomosis or ostomy, inadequate surgery (oncologically or inadequate debridement), inadequate hemostasis, improper surgical technique, improper drainage (inadequate or unnecessary), and improper wound closure. According to the authors' functional outcome assessment, most patients (80.2%) fully recovered from the complications, while 4.7% had residual functional impairment, and 15.1% died.

Discussion

One of the most invaluable surgical conferences is undoubtedly the morbidity and mortality conference, since it helps assessing the quality of care, improving medical knowledge of the attendants, and it could help prevent reoccurrence of the complications. Several studies have assessed and classified the surgical complications in terms of severity⁽¹⁻⁴⁾. However, to prevent reoccurrence of the complications, one should also assess the preventability and the root causes of the complications since data show that up to 50% of surgical complications are preventable^(5,6). Surprisingly, the present study showed that 89% of surgical complications were preventable or potentially preventable as per the authors' surgical faculties' judgment.

RCA is an investigation to identify the cause(s) of a complication. The goals of RCA are to find out what happened, why did it happen, and how to prevent its reoccurrence⁽⁷⁾. A number of studies have tried to identify root causes of surgical complications, which could be categorized in many ways, such as human

factors versus systemic factors, anesthesia versus surgery, and surgical technique failures versus other diagnostic or treatment failures⁽⁸⁻¹¹⁾. However, there is no single standardized RCA classification that has been universally accepted and used to analyze the root causes of surgical complications. Hence, the investigators tended to come up with one's own RCA classification to suit their surgical populations. For instance, anesthesia versus surgery RCA was used in the study assessing unplanned admission to surgical intensive care unit⁽⁸⁾ while surgical technique failures versus other diagnostic or treatment failure RCA was used in the trauma study⁽⁹⁾.

In the present study, the authors have invented a new RCA classification according to the period that the corrective action could have been introduced to prevent the complications. This was based on five periods, i.e., diagnosis, management decision making, preoperative, intraoperative, and postoperative periods. The authors found that this classification was quite simple and easy to use for the general surgical or trauma population. Interestingly, the authors identified that defect in intraoperative management was the most common root cause for the preventable or potentially preventable complications (61.3%), and more than half of these were results of inappropriate surgical approach or technique. This may emphasize that knowledge to choose the correct operation and skill to perform it appropriately are of the utmost importance for surgical training.

There are some limitations of the present study that deserve to be mentioned. Firstly, the present study was a retrospective-descriptive study in a single institution, thus comparison of the results with other institution could not be performed. Secondly, the judgment on preventability and RCA were made solely by the authors' surgical faculties; hence, the results were subjective and arguable, especially for the potentially preventable complications. For

example, a grade one pancreatic fistula occurring after a pancreatic surgery may be considered by some surgeons as “a sequela (unpreventable)” but it would be considered as “a potentially preventable complication” by the authors’ surgical faculties, if there was a corrective action that could have been done to change the outcome such as identifying and suturing of the pancreatic duct. This may have contributed to high number of potentially preventable complications in the present study.

Conclusion

The present study demonstrated that most complications in general surgery were preventable or potentially preventable. RCA showed that the most common root cause was the defect in intraoperative management, especially, inappropriate surgical approach or technique. Therefore, knowledge of choosing the correct operation and skill to perform it appropriately are the utmost important for surgical training.

What is already known in this topic?

Surgery, like other methods of treatment, could result in complications. Several studies have assessed and classified the surgical complications in terms of severity. However, to prevent reoccurrence of the complications, one should also assess preventability and the root causes of the complications since data shows that up to 50% of surgical complications are preventable. Number of studies have tried to identify root causes of surgical complications, which could be categorized in many ways. However, there is no single standardized RCA classification that has been universally accepted and used to analyze the root causes of surgical complications.

What this study adds?

In the present study, the authors analyzed the General Surgery morbidity and mortality conferences in King Chulalongkorn Memorial Hospital to identify preventability and root causes of the complications using a novel RCA classification according to the period that the corrective action could have been introduced to prevent the complications, as during 1) diagnosis, 2) management decision making, 3) preoperative, 4) intraoperative, and 5) postoperative periods. The present study showed that 89% of surgical complications were preventable or potentially

preventable. The RCA showed that the most common root cause was defect in intraoperative management (61.3%), especially inappropriate surgical approach or technique. Therefore, knowledge of choosing the correct operation and skill to perform appropriately is of the utmost importance for surgical training.

Conflicts of interest

The authors hereby certify that there is no conflict of interest in the present study.

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