International Journal of Cardiovascular and Thoracic Surgery
2024; Vol. 10, No. 1, pp. 6-13
https://doi.org/10.11648/j.ijcts.20241001.12

Review Article

Application of Clavien-Dindo Complications Classification in Cardiac Surgery Practice: A Narrative Review

Phan Quang Thuan*

Department of Adult Cardiovascular Surgery, University Medical Center, Ho Chi Minh City, Vietnam

Abstract

Background: Cardiac surgery is a complex medical specialty known for its potential complications, necessitating accurate evaluation and reporting. Current prediction scales have limitations in capturing the full spectrum of complications experienced by patients undergoing cardiac surgery. The Clavien-Dindo Complications Classification (CDCC) and the Comprehensive Complications Index (CCI) have emerged as promising tools for assessing complications in various surgical specialties, including cardiac surgery. Method: This comprehensive review synthesizes the available literature to assess the application of CDCC and CCI in the context of cardiac surgery. The effectiveness of CDCC and CCI in measuring the nature and clinical impact of complications in this specialized field is explored. Additionally, methods from other medical specialties are reviewed to enhance our understanding of the practical implementation of these classification systems in cardiac surgery. Results: The present study, including significant contributions by Mélanie Hébert et al., highlights the potential of CDCC and CCI to quantify both the number and severity of complications in adult cardiac surgery. Their utility in this specialized field presents opportunities for robust data collection and outcome evaluation. Conclusion: While the application of CDCC and CCI in cardiac surgery shows promise, the notable scarcity of comprehensive evaluation studies has hindered the accessibility of these systems to clinicians. This study provides a clear and accessible reference for healthcare professionals seeking to integrate CDCC and CCI into their cardiac surgery practice. Additionally, we propose the need for guideline studies to address this gap in the field.

Keywords

Cardiac Surgery, Clavien-Dindo Complications Classification (CDCC), Comprehensive Complications Index (CCI)

1. Introduction

Cardiac surgery, a formidable surgical procedure, entails significant potential for complications [1]. Various predictive scales, such as The Society of Thoracic Surgeons (STS) score and Euro score II, have been developed to forecast complications following cardiac surgery [2]. Nevertheless, these scores fall short in capturing the actual occurrence and impact of complications in patients.

The Clavien-Dindo Complications Classification (CDCC) and the Comprehensive Complication Index (CCI) have proven effective in assessing the nature and clinical consequences of complications, and have been successfully integrated into outcome reporting protocols and guidelines across different surgical specialties [3-6]. Research conducted in the realm of cardiac surgery has demonstrated their utility in measuring complications, yielding positive results [7]. However, a dearth of comprehensive review studies on the

*Corresponding author: phanquangthuan.md@gmail.com (Phan Quang Thuan)

Received: 12 April 2024; **Accepted:** 3 May 2024; **Published:** 17 May 2024

application of CDCC and CCI within the domain of cardiac surgery has made it challenging for clinicians to access practical guidance.

This study seeks to bridge this gap by conducting a comprehensive review of articles that pertain to Clavien-Dindo and the application of this classification system in the context of cardiac surgery. Furthermore, it explores evaluation methodologies from other medical specialties to consolidate the evidence supporting the practical implementation of CDCC and CCI in cardiac surgery, making this valuable practice more transparent and accessible for healthcare professionals.

2. Clavien-Dindo Complications Classification

The Clavien-Dindo Complications Classification is a well-established tool extensively employed in the scientific literature for categorizing surgical complications. This classification system organizes complications according to the extent of intervention needed for their resolution, and its strength lies in its straightforwardness and user-friendliness, qualities that bolster its impressive inter-rater reliability [8, 9].

In 1992, a classification system was introduced to distinguish between "complications," "failure to cure," and "sequelae" following surgical procedures. "Failure to cure" referred to the inability to achieve the operation's primary goal, while "sequelae" encompassed events inherent to the procedure. All other negative events fell under "complications," with severity based on the invasiveness of required corrective therapy. This system was later refined into the CDCC after a decade of routine application in various centers. It now comprises 5 severity grades (table 1) and has been widely utilized and validated in numerous surgical studies [10-12].

Cardiac surgery is a distinctive surgical procedure that significantly affects multiple organs in the body, especially when cardiopulmonary bypass is employed. Postoperative care in cardiac surgery differs notably from other surgical specialties. The utilization of the CDCC to assess outcomes in cardiac surgery was adapted, as suggested by Mélanie Hébert et al, and is illustrated in Table 2 [7].

Table 1. *Classification of Surgical Complications.*

Grade	Definition
I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological 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 anaesthesia
IIIb	Intervention under general anaesthesia
IV	Life-threatening complication (including CNS complications)* requiring IC/ICU management
IVa	Single organ dysfunction (including dialysis)
IVb	Multiorgan dysfunction
V	Death of a patient
Suffix "d"	If the patient suffers from a complication at the time of discharge (see examples in Table 2), 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.

*Brain haemorrhage, ischemic stroke, subarachnoid bleeding, but excluding transient ischemic attacks.
CNS, central nervous system; IC, intermediate care; ICU, intensive care unit

Table 2. *Modified Clavien-Dindo Complications Classification in cardiac surgery.*

Grade	Definition
I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions Allowed therapeutic regimens are as follows: drugs as antihypertensives, antiarrhythmics, vasopressors, vasodilators, antiemetics, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy; also includes wound infections opened at the bedside and transfusion of 1 or 2 units of blood
II	Requiring pharmacological treatment with drugs other than those included for grade I complications Blood transfusions (≥3 transfusions) and total parenteral nutrition are included
III	Requiring surgical, endoscopic or radiological intervention
IIIa	Intervention not under general anaesthesia
IIIb	Intervention under general anaesthesia
IV	Life-threatening complication (including CNS complications)* requiring IC/ICU management
IVa	Single organ dysfunction (including dialysis)
IVb	Multiorgan dysfunction
V	Death of a patient

*Brain haemorrhage, ischemic stroke, subarachnoid bleeding, but excluding transient ischemic attacks.
Adapted from Dindo et al with modifications in bold.
CNS, central nervous system; IC, intermediate care; ICU, intensive care unit

3. Criteria for Grading Surgical Cardiac Complications

All postoperative complications, defined in accordance with the CDCC as any deviation from the ideal surgical recovery of a patient, were assessed [12, 13]. This is particularly crucial in cardiac surgery, where establishing the definition of normal postoperative conditions proves challenging. Author Mélanie Hébert et al modified the CDCC to include any deviation from the standard administration of antihypertensives, antiarrhythmics, vasopressors, and vasodilators after cardiac surgery, which is classified as Grade I [7, 14]. This modification is warranted because the use of antihypertensives, antiarrhythmics, vasopressors, and vasodilators is nearly routine following cardiac surgery [15, 16]. Additionally, many studies consider a blood transfusion of 1 to 2 units not excessive after heart surgery, further underscoring the importance of defining a normal surgical course [17]. The patient's outcome will be affected by massive blood transfusions [18]. Establishing this norm can be based on prior research, cardiac surgery textbooks, or the consensus of an ad hoc committee. For instance, in the study by author Mélanie Hébert et al, a panel of three cardiac surgeons monitored and assessed cases based on consensus [7].

Complications should be new issues that arise after surgery, distinct from pre-existing pathological conditions. For example, a patient with end-stage chronic kidney failure may already be undergoing regular dialysis before cardiac surgery. After the surgery, it is necessary to continue dialysis, which was planned in the preoperative stage. In such cases, this continuation of dialysis is not considered a complication following cardiac surgery. This is because dialysis is an essential and pre-planned treatment for the patient, and the choice of Continuous Renal Replacement Therapy is made to facilitate the process of hemodynamic adjustment.

In the evaluation of complications following cardiac surgery using CDCC, the consensus of an ad hoc committee plays a pivotal role. Similarly, in many other medical specialties, establishing standard postoperative conditions is crucial for optimizing patient care. Doctors can readily incorporate CDCC into their clinical practice, minimizing personal bias [4, 5]. A key advantage of this approach is that certain fundamental principles apply. First, committee members should possess extensive experience and flexibility in managing cases. Second, they should adhere to CDCC's general classification standards while making appropriate adjustments tailored to their field of expertise. Third, the committee should consist of an odd number of members, ensuring an even number of votes in favor. Finally, decisions are ideally reached through unanimous consensus. If unanimity isn't achieved, ongoing adjustments and deliberations are necessary [4]. In some medical specialties, scientific committees are also instrumental in developing guidelines for implementing CDCC [5]. This experience is equally applica-

ble in the realm of cardiac surgery.

The principles of assessment during the postoperative period involve evaluating complications as they occur and monitoring their progression before discharge. When using the CDCC, if a complication advances through multiple grades and becomes increasingly severe over time, the highest grade is selected for assessment at the time of discharge [19, 20]. This approach is entirely justified because it allows us to focus on evaluating and measuring the most severe consequences of the event on the patient, thus capturing its full impact.

Furthermore, if a patient experiences complications during the postoperative period that are a result of a different intervention unrelated to the surgery itself, these complications are still subject to evaluation. This is because without the initial surgery, the patient would not have been in the postoperative setting where these complications could develop. Similarly, if a patient is diagnosed with a new condition during the postoperative period necessitating intervention or requires transfer to another department due to preexisting complications, these situations also warrant assessment using the CDCC. In cases of fatal complications, whether they occur during surgery or after transfer to another department or hospital, they are all subject to evaluation using the CDCC [19].

4. Assessment of Particular Instances

Drawing from the principles outlined and the research conducted by authors Mélanie Hébert et al and Pierre A. Clavien et al, Table 3 provides examples involving patients undergoing cardiac surgery [7, 19].

Table 3. *Assessment of particular instances.*

	PD1		PD3		PD4		PD5		Grade discharge	CCI
Patient 1	Nausea and vomiting	I	No		No		No		I	8.7
Patien 2	Postoperative bleeding required 1 unit of blood transfusion	I	Postoperative bleeding required 3 unit of blood transfusion	II	Postoperative bleeding requires surgery under general anesthesia	IIb	No		IIIb	33.7
Patient 3	No		Pneumothorax due to central line procedure	IIIa	No		No		IIIa	26.2
Patient 4	Epileptic	I	Brain hemorrhage	IVa	No		No		IVa	42.4
Patient 5	Wound infection	I	Deep venous thrombosis	II	Acute prosthetic valve regurgitation	IIIb	Stroke	IVa	I, II, IIIb, IVa	58.7
Patient 6	Myocardial infarction caused by occlusion after coronary artery bypass surgery Cardiac Shock	IIIb IVa	Renal failure	IVb	Deep venous thrombosis	II	Dead	V	V, II	100
	Complications	Grade 1	Complications	Grade 2	Complications	Grade 3	Complications	Grade 4		

PD: Postoperative day, The Comprehensive Complication Index (CCI) can be calculated using the website https://www.cci-calculator.com/cciCalculator, Grade 1: Grade at PD1, Grade 2: Grade at PD3, Grade 3: Grade at PD4, Grade 4: Grade at PD5

5. Comprehensive Complication Index

The Comprehensive Complication Index (CCI) represents an extension of the Clavien-Dindo classification, enabling the generation of a morbidity score ranging from 0 to 100. This adaptation has been put forward as a potentially superior approach for evaluating the overall morbidity impact of surgical procedures [9]. In many other surgical procedures, the CCI has demonstrated superior predictive capabilities concerning in-hospital costs, length of hospital stays, treatment quality, and the assessment of complications compared to the CDCC [21, 22]. However, in the field of cardiac surgery, there has been no study that directly compares CCI with CDCC. In a study conducted by author Mélanie Hébert et al, it was discovered that an increase in CDCC/CCI is associated with a higher prevalence of comorbidities, longer surgical durations, extended lengths of hospital stay, and greater procedure complexity. This observation accurately reflects the intricacies of the surgical journey in adult cardiac surgery [7].

When a complication progresses gradually, the CCI is calculated based on the most severe grade assigned to that complication. This approach aligns with CDCC's method of recording grades to accurately assess the impact of complications on patients [19]. The CCI is cumulative for various complications, with Table 3 providing examples of CCI calculations for different cases.

6. Evidence Deficiency in Cardiac Surgery

Currently, limited research has been conducted on the application of the CDCC in cardiac surgery, despite its widespread use in other medical specialties. Mélanie Hébert and her colleagues explored the application of CDCC and the CCI in cardiac surgery, albeit without including cases of emergency surgery and congenital heart disease. The initial findings of their study demonstrate that CDCC and CCI effectively quantify both the number and severity of complications in adult cardiac surgery, offering numerous research opportunities for other institutions to contribute valuable data to the field of cardiac surgery [7].

Nonetheless, the lack of research on the application of CDCC in aortic surgery, congenital heart disease, and emergency cardiac surgery has hindered our ability to gain a comprehensive understanding of the complications associated with these procedures. Looking ahead, it is imperative that these specific areas receive focused research attention, as this will provide critical evidence for clinical practice and enhance patient care in these specialized realms of cardiac surgery.

7. Recommendations and Future Studies

Cardiac surgery is inherently complex, involving a wide array of procedures and unique patient characteristics. Complications in this field are often multifaceted and may not fit neatly into the existing classification. This challenge necessitates a comprehensive approach that considers cardiac-specific intricacies, highlighting the need for more research.

Addressing evidence scarcity requires a concerted effort from the cardiac surgery community. Robust research initiatives must be undertaken to establish a more solid foundation for the Clavien-Dindo Classification's use in this field. These endeavors should involve comprehensive data collection, detailed complication analysis, and a focus on the specific nuances of cardiac surgery.

To address this issue, collaborative research is vital. Cardiac surgeons, researchers, and healthcare institutions should come together to initiate large-scale, multicenter studies that focus on complication classification and outcomes. The development of standardized reporting systems specific to cardiac surgery can aid in data collection and analysis, enabling a more accurate classification of complications.

Moreover, incorporating complication data into existing cardiac surgery registries can streamline data collection efforts and enhance the evidence pool. To further enhance the field, it is crucial to establish criteria for normal conditions after cardiac surgery. Rigorous scientific analysis or input from professional councils should guide this research effort.

In addition, researchers should assess the effectiveness of the consensus-adjusted CDCC score when applied to cardiac surgery outcomes. Such an investigation will help determine if this score can provide accurate and comprehensive insights into the field.

Furthermore, it is important to conduct research on the application of CDCC and the CCI in aortic and emergency cardiac surgery to assess their effectiveness in these specific contexts.

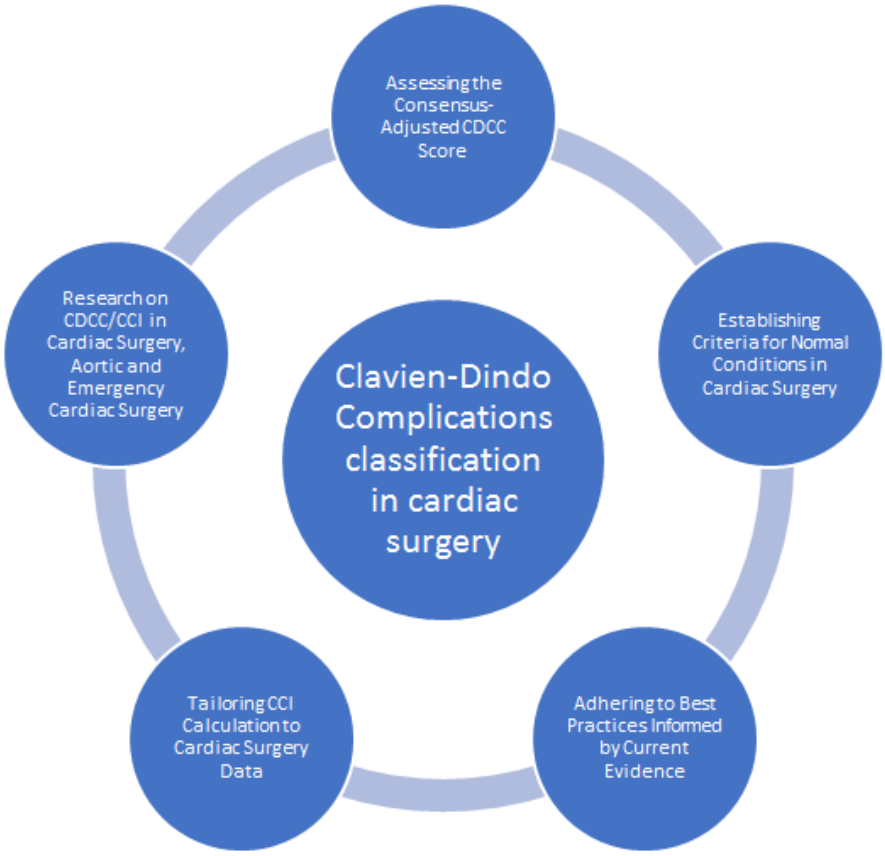

Figure 1. *Clavien-Dindo Complications Classification in Cardiac Surgery Practice.*

Last but not least, there is a need to tailor the CCI calculation to align with data collected from cardiac surgery patients. This adaptation ensures that the CCI score is in harmony with the unique characteristics of cardiac surgery cases. Collectively, these research efforts aim to enhance the understanding and evaluation of complications in the intricate domain of cardiac surgery, ultimately improving patient care and outcomes.

8. Conclusion

In conclusion, the utilization of the CDCC in cardiac surgery, although a promising avenue, faces a significant challenge - the scarcity of comprehensive research and data. While CDCC has demonstrated its efficacy in various medical specialties, its application in the context of cardiac surgery remains underexplored. Mélanie Hébert et al preliminary research provides valuable insights into the potential of CDCC in quantifying the number and severity of complications in adult cardiac surgery. However, their study's focus on non-emergency cases and those not related to congenital heart disease underscores the pressing need for further research.

To address this gap, the cardiac surgery community must embark on collaborative and rigorous research initiatives. These efforts should encompass the incorporation of CDCC in aortic surgery, congenital heart disease cases, and emergency cardiac surgery. The development of standardized reporting systems specific to cardiac surgery and integration with existing registries can streamline data collection efforts. By expanding the scope of research in these areas, we can bridge the evidence gap and provide crucial data for clinical practice. The journey to refining the application of CDCC in cardiac surgery is an ongoing one, marked by collaborative research, adaptation, and the unwavering commitment to improving patient care in this specialized field.

Abbreviations

CDCC: Clavien-Dindo Complications Classification
CCI: Comprehensive Complications Index
STS: The Society of Thoracic Surgeons

Author Contributions

Phan Quang Thuan is the sole author. The author read and approved the final manuscript.

Funding

No funding was received for this study.

Data Availability Statement

All of the material is available and owned by the authors and/or no permissions are required.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Udzik J, Sienkiewicz S, Biskupski A, Szylińska A, Kowalska Z, Biskupski P. Cardiac Complications Following Cardiac Surgery Procedures. J Clin Med. 2020; 9(10). https://doi.org/10.3390/jcm9103347

[2] Sinha S, Dimagli A, Dixon L, Gaudino M, Caputo M, Vohra HA, Angelini G, Benedetto U. Systematic review and meta-analysis of mortality risk prediction models in adult cardiac surgery. Interactive CardioVascular and Thoracic Surgery. 2021; 33(5): 673-686. https://doi.org/10.1093/icvts/ivab151

[3] Bolliger M, Kroehnert JA, Molineus F, Kandioler D, Schindl M, Riss P. Experiences with the standardized classification of surgical complications (Clavien-Dindo) in general surgery patients. Eur Surg. 2018; 50(6): 256-261. https://doi.org/10.1007/s10353-018-0551-z

[4] Katayama H, Kurokawa Y, Nakamura K, Ito H, Kanemitsu Y, Masuda N, Tsubosa Y, Satoh T, Yokomizo A, Fukuda H, Sasako M. Extended Clavien-Dindo classification of surgical complications: Japan Clinical Oncology Group postoperative complications criteria. Surg Today. 2016; 46(6): 668-685. https://doi.org/10.1007/s00595-015-1236-x

[5] Mitropoulos D, Artibani W, Biyani CS, Bjerggaard Jensen J, Roupr â M, Truss M. Validation of the Clavien-Dindo Grading System in Urology by the European Association of Urology Guidelines Ad Hoc Panel. Eur Urol Focus. 2018; 4(4): 608-613. https://doi.org/10.1016/j.euf.2017.02.014

[6] Degerli MS, Canturk AO, Bozkurt H, Alpay O, Akinci M, Altundal YE, Yildiz T, Yildirim D. Systematic assessment of complications after laparoscopic colorectal surgery for advanced colorectal cancer: A retrospective study using Clavien-Dindo classification, 5-year experience. Malawi Med J. 2022; 34(1): 49-52. https://doi.org/10.4314/mmj.v34i1.9

[7] H ébert M, Cartier R, Dagenais F, Langlois Y, Coutu M, Noiseux N, El-Hamamsy I, Stevens LM. Standardizing Postoperative Complications-Validating the Clavien-Dindo Complications Classification in Cardiac Surgery. Semin Thorac Cardiovasc Surg. 2021; 33(2): 443-451. https://doi.org/10.1053/j.semtcvs.2020.09.029

[8] Wang WG, Babu SR, Wang L, Chen Y, Tian BL, He HB. Use of Clavien-Dindo classification in evaluating complications following pancreaticoduodenectomy in 1,056 cases: A retrospective analysis from one single institution. Oncol Lett. 2018; 16(2): 2023-2029. https://doi.org/10.3892/ol.2018.8798

[9] Golder H, Casanova D, Papalois V. Evaluation of the usefulness of the Clavien-Dindo classification of surgical complications. Cir Esp (Engl Ed). 2023; 101(9): 637-642. https://doi.org/10.1016/j.cireng.2023.02.002

[10] Idriss AM, Tfeil Y, Baba JS, Boukhary SM, Deddah MA. [Applicability of the Clavien-Dindo classification in the evaluation of postoperative complications at the Surgery Department of the National Hospital Center of Nouakchott: observational study of 834 cases]. Pan Afr Med J. 2019; 33254. https://doi.org/10.11604/pamj.2019.33.254.18024

[11] Slankamenac K, Graf R, Barkun J, Puhan MA, Clavien PA. The comprehensive complication index: a novel continuous scale to measure surgical morbidity. Ann Surg. 2013; 258(1): 1-7. https://doi.org/10.1097/SLA.0b013e318296c732

[12] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004; 240(2): 205-213. https://doi.org/10.1097/01.sla.0000133083.54934.ae

[13] Yoon PD, Chalasani V, Woo HH. Use of Clavien-Dindo classification in reporting and grading complications after urological surgical procedures: analysis of 2010 to 2012. J Urol. 2013; 190(4): 1271-1274. https://doi.org/10.1016/j.juro.2013.04.025

[14] H ébert M, Cartier R, El-Hamamsy I, Dagenais F, Langlois Y, de Varennes B, Greentree D, Stevens L. AN ADAPTED CLAVIEN-DINDO CLASSIFICATION AND COMPREHENSIVE COMPLICATIONS INDEX RELIABLY REPRESENT EARLY POSTOPERATIVE OUTCOMES IN CARDIAC SURGERY. Canadian Journal of Cardiology. 2019; 35(10): S165. https://doi.org/10.1016/j.cjca.2019.07.318

[15] Vail EA, Shieh MS, Pekow PS, Gershengorn HB, Walkey AJ, Lindenauer PK, Wunsch H. Use of Vasoactive Medications after Cardiac Surgery in the United States. Ann Am Thorac Soc. 2021; 18(1): 103-111. https://doi.org/10.1513/AnnalsATS.202005-465OC

[16] Schoonen A, van Klei WA, van Wolfswinkel L, van Loon K. Definitions of low cardiac output syndrome after cardiac surgery and their effect on the incidence of intraoperative LCOS: A literature review and cohort study. Front Cardiovasc Med. 2022; 9926957. https://doi.org/10.3389/fcvm.2022.926957

[17] Hajjar LA, Vincent J-L, Galas FRBG, Nakamura RE, Silva CMP, Santos MH, Fukushima J, Filho RK, Sierra DB, Lopes NH, et al. Transfusion Requirements After Cardiac Surgery: The TRACS Randomized Controlled Trial. JAMA. 2010; 304(14): 1559-1567. https://doi.org/10.1001/jama.2010.1446

[18] Engoren MC, Habib RH, Zacharias A, Schwann TA, Riordan CJ, Durham SJ. Effect of blood transfusion on long-term survival after cardiac operation. The Annals of Thoracic Surgery. 2002; 74(4): 1180-1186. https://doi.org/10.1016/S0003-4975(02)03766-9

[19] Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santiba ñes E, Pekolj J, Slankamenac K, Bassi C, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009; 250(2): 187-196. https://doi.org/10.1097/SLA.0b013e3181b13ca2

[20] Dekker A, Crawford HA, Stott NS. How Do Complications Within the First 30 days after Spinal Deformity Surgery in Children with Cerebral Palsy Affect Length of Stay? Clin Orthop Relat Res. 2021; 479(2): 366-375. https://doi.org/10.1097/corr.0000000000001290

[21] Smeyers K, Slankamenac K, Houben B, Sergeant G. Comparison of the Clavien-Dindo and Comprehensive Complication Index systems for grading of surgical complications after colorectal resections. Acta Chir Belg. 2022; 122(6): 403-410. https://doi.org/10.1080/00015458.2021.1920682

[22] Kim T-H, Suh Y-S, Huh Y-J, Son Y-G, Park J-H, Yang J-Y, Kong S-H, Ahn HS, Lee H-J, Slankamenac K, et al. The comprehensive complication index (CCI) is a more sensitive complication index than the conventional Clavien–Dindo classification in radical gastric cancer surgery. Gastric Cancer. 2018; 21(1): 171-181. https://doi.org/10.1007/s10120-017-0728-3