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Design and implementation of a fully electronic surgery database based on Google tools: an initial experience in cardiovascular surgery.

Criação e implementação de um banco de dados cirúrgico totalmente informatizado baseado nas ferramentas Google: experiência inicial em cirurgia cardiovascular.

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A B S T R A C T

Objective: to describe, in a practical and step-by-step manner, the construction of a fully electronic platform for data collection, storage, and analysis, initially proposed for cardiovascular surgery, with interfaces that are reproducible and applicable to other surgical specialties, as well as to present the initial work experience with this instrument in cardiac surgery and the preliminary results obtained after its implementation in a Brazilian tertiary university hospital. **Methods:** the platform was developed based on Google tools, which are free, easy to use, and widely accessible. From the beginning of this initiative, in May 2015, to the preliminary analysis, in February 2017, data from 271 consecutive patients submitted to cardiovascular surgery were prospectively recorded and preliminarily analyzed. **Results:** the initiative was implemented with full success, with 100% of patients included and without loss of any variable, in a database composed of more than 500 variables. The most frequent immediate postoperative complications were: atrial fibrillation (22.5%), bronchopneumonia (10.7%), delirium (10.3%), acute renal failure (10%), stroke (5%), and death (7%). Comparing mortality rates in the first and second years of the initiative, a reduction from 10.8% to 4% (p=0.042), respectively, was evidenced. **Conclusion:** the new proposal of data collection and storage presented in this work was fully feasible and effective. It may be useful to other surgical specialties that wish to develop methods to evaluate success and postoperative complication rates, as well as quality improvement programs.

Keywords: Cardiovascular Surgical Procedures. Database. Education. Quality of Health Care.

INTRODUCTION

Despite constant improvements in health technology systems, high-quality standards in health care can only be achieved through a collective effort objecting the improvement of critical points related to specific outcomes. Surgical patient databases are the essential basis for the development of any surgical quality improvement program, a worldwide trend in search of higher quality of care and safety in the management of surgical patients[1]. With Brazilian surgical specialties seeking a greater insertion in the international surgical community, an important step towards high-quality standards is the creation and maintenance of well-prepared institutional databases, readily accessible and with practical applicability[2].

However, data acquisition is a challenging process, since the routinely collected variables are incomplete, fragmented, and difficult to access (stored as text and paper spreadsheets), susceptible to errors and losses[3]. An electronic data platform would allow access to institutional statistics in real time to both health professionals and patients themselves, and would ultimately allow the comparison of these results with those of other services considered national and international standards. Fully electronic, readily

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accessible, fast, and easy to fill database systems, which do not require medical record review and serve as a secure, reliable, and practical database, could therefore leverage medical-surgical scientific production and contribute to the improvement of surgical quality.

In cardiovascular surgery, one of the pioneer specialties in this subject, the implementation of quality improvement programs has been showing to be able to reduce infection rates, cardiac tamponade, mechanical ventilation time (MV), hospitalization in an intensive care unit (ICU), and, especially, postoperative mortality[4-6].

Currently, there are many databases which are available for data collection in cardiovascular surgery; however, most of them present issues that undermine their true goals – quality improvement in a global, non-exclusionary, way.

Google Drive is a free online service that allows its users to create questionnaires using tools known as "Google Forms." These questionnaires can be electronically distributed to various individuals involved in the data collection process. The use of Google Drive makes it possible to collect data in a simplified manner, saving time and providing flexibility to researchers in a totally paperless environment[7].

In this article, we review all the steps for building a fully electronic database, initially developed for data storage in cardiovascular surgery, using exclusively Google tools. In addition, we describe our initial work experience with this new platform in a Brazilian tertiary university hospital.

METHODS

When we realized the need to catalog data concerning the accomplishment of cardiovascular surgeries, a study group was formed in order to review medical literature and discuss the topic. After reviewing the already established databases, we chose to use the variables of The Society of Thoracic Surgeons (STS) database[8], adapted to local needs and particularities, as bases.

Established in 1989, STS database is one of the most comprehensive records of clinical data in health care. It is widely considered a gold-standard for the evaluation of risk-adjusted results in cardiovascular surgery and the basis for all STS[9] quality improvement and measurement activities. For this reason, we chose it as basis for the development of this initiative.

Thus, we created the initial forms referring to four periods of interest - preoperative, intraoperative, ICU, and postoperative -, using "Google Forms" tool (Figure 1A). This tool allows the creation of forms identified by title and constants of objective questions and standard answers, previously defined by the owner (text, simple choice, multiple choice, date, etc.), as shown in figure 1B.

Google Drive tool was conveniently chosen to host the forms because it is an online platform, available for Windows, Mac, mobile (Android and iOS), which allows file storage in Google Cloud, as well as access and upload through any device connected to the internet. Storage in the software is free and the interface for use is simple, self-explanatory, and integrated with other Google services[10].

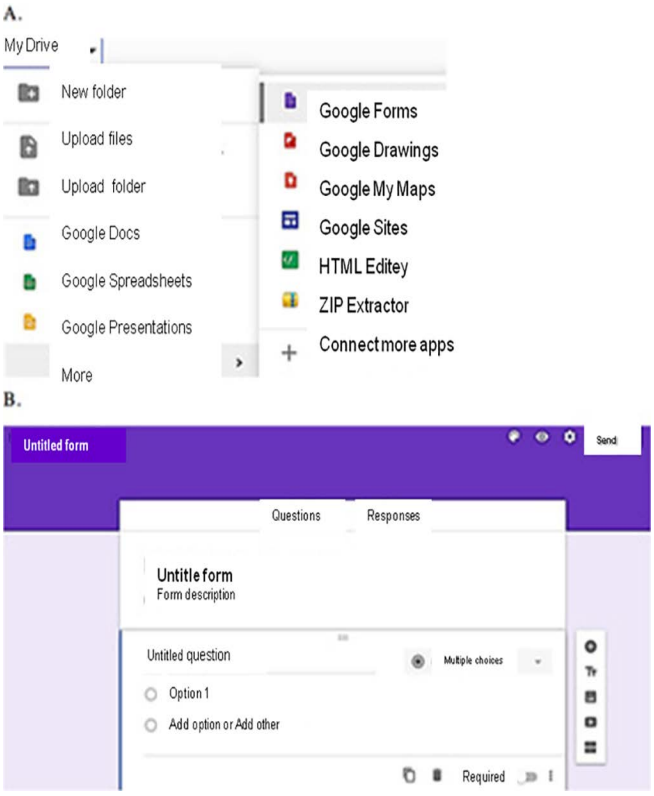

Figure 1. *A: creating forms; B: editing forms.*

The next step was the creation of a specific website entitled "Cardiovascular Surgery Database" to house the four forms that were then exported from Google Drive to the website, following this sequence of commands: "insert", "drive", and "form" (Figure 2). The website was then shared with the other contributors clicking on the "share" and "sharing and permissions" tabs. Access to Google Sites was carried out through <https://sites.google.com/> utilizing personal users and passwords. In this work, only users who were previously authorized by the principal investigator obtained access to the site.

The researchers involved in this initiative were able to enter data from any device connected to the internet by accessing the hyperlink of the website. As the forms were being filled in, response statistics could be viewed through the "answers" item, "summary of answers" subtopics,

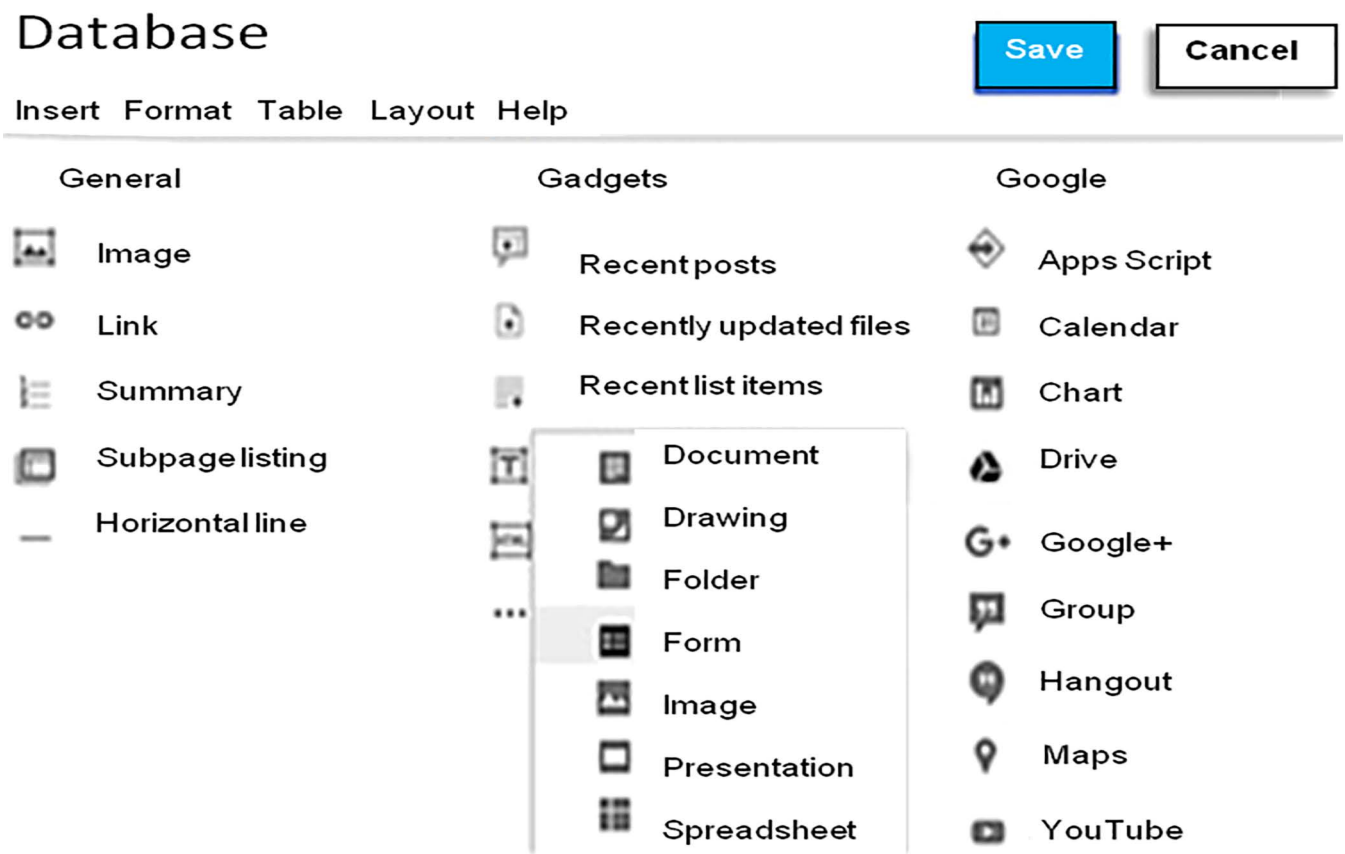

Figure 2. *Embedding forms in the site.*

or "see answers" (Figure 3A). The first icon was used to generate summary charts of responses for quick and real-time analyses, while the second generated data spreadsheets that could be exported in different formats, such as Microsoft Excel (.xlsx), PDF documents (.pdf), and Open Document Format (.ods) (Figure 3B).

It is noteworthy that only the responsible researchers had access to the filled-in forms. After being filled in by the other associated researchers, the answers could no longer be accessed or edited. Data were weekly exported and checked by an independent reviewer. During this process, the collected variables were compared to the constants in the patients' electronic medical records, to ensure that all information had been adequately filled in. Data identified as "potential fulfillment errors" were reviewed again and, if necessary, corrected by a third investigator.

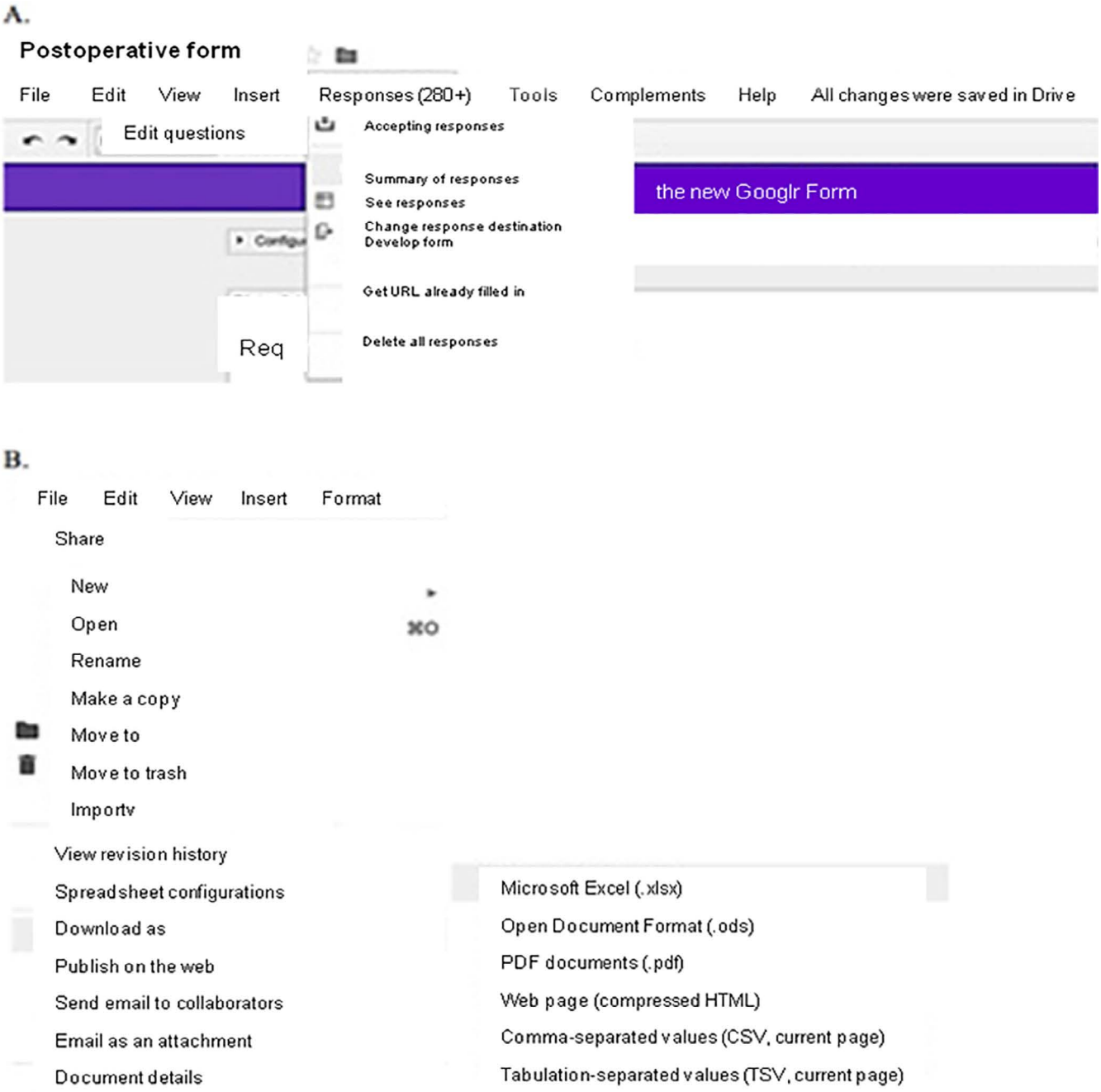

Figure 3. *A: summary view of responses; B: file export.*

This process was designed to avoid loss or manipulation of variables, which could distort actual results.

Quarterly, data were analyzed by merging the four answer spreadsheets generated in "Microsoft Excel" (.xlsx) program, with subsequent export to the Statistical Package for the Social Sciences - SPSS (.sav) 18.0 program. Preliminary results derived from these analyses were used to establish actions focused on correcting potential quality deviations associated with negative outcomes. Another objective of these meetings was motivational, since the knowledge of success rates and failures contributed to keep the surgeons of the group involved, both in the adequate filling of the variables and in the constant search for improvement of their own surgical practices.

The primary objective of this study was to describe, in a practical and detailed manner, all steps related to the creation and implementation of a fully electronic database, initially designed for cardiovascular surgery. The secondary objective was to describe the initial work experience with this new platform, presenting preliminary results generated after its implantation in a Brazilian university hospital. Early postoperative outcomes were defined as occurring during the target surgical hospitalization or within 30 days after the procedure.

All patients undergoing cardiovascular surgeries with extracorporeal circulation at Hospital de Clínicas de Porto Alegre were invited to participate in the project. Only those patients who did not agree to participate in the study or to sign the free and informed consent form were excluded. The project was approved by the Research Ethics Committee of the institution (number: 15-0332).

In agreement with Data Protection Action, all patients were anonymously registered, being identified in the database only by number and date of birth. Therefore, even in case of exposure of any of the data, patients' identities could not be revealed.

Data were collected through the forms described above, transferred and analyzed in SPSS 18.0 program. The descriptive analysis for the quantitative variables was performed using mean (M) and standard deviation (SD) or median (Md) and interquartile range (IQR), when applied. Qualitative variables were reported through absolute and relative frequency distribution.

Comparison of mortality between the first and second years of the initiative was performed through the chi-square test. Univariate analysis was initially performed to identify other variables associated with the outcome. Variables of clinical importance or with p-value <0.20 were included in multivariate analysis. P-value <0.05 was considered significant.

RESULTS

From the beginning of this initiative, in May 2015, to the preliminary analysis, in February 2017, 271 participants were enrolled.

A 100% inclusion rate of patients operated in this period was achieved, without loss of any variable, in a database composed of more than 500 variables (235 preoperative, 170 intraoperative, 37 ICU, and 73 postoperative variables).

Among enrolled participants, 62% (168) were men and the mean age was 61.3±12 years. Other baseline characteristics can be found in table 1. Almost half of the procedures (44%) was performed in urgency and emergency characters. The main causes were acute myocardial infarction (27%), unstable angina (17.5%), infective endocarditis (11.6%), decompensated heart failure (10%), and acute aortic dissection (6.7%).

Table 1. *Baseline characteristics of the enrolled population.*

Preoperative variables	N=271
Age – years	
Mean ± standard deviation	61.3±12
Male gender – n (%)	168 (62)
Race*– n (%)	
White	251 (92.6)
Afrodescendant or others	20 (7.4)
Weight – Kg	
Mean ± standard deviation	74±15
Height – cm	
Mean ± standard deviation	165±10
EuroSCORE II**	
Median – %	2.1
Interquartile range	1.0-4.5
STS***score	
Median - %	1.3
Interquartile range	0.7-3.0
Acute myocardial infarction – n (%)	72 (27)
Systemic arterial hypertension – n (%)	203 (75)
Dyslipidemia – n (%)	132 (49)
Diabetes *mellitus*– n (%)	83 (30)
Current smoking – n (%)	47 (17)
Chronic renal failure – n (%)	37 (14)
Stroke – n (%)	37 (14)
Cardiac arrhythmia – n (%)	37 (14)
Previous cardiac surgery – n (%)	25 (9)
Fraction of left ventricular ejection	
Mean ± standard deviation	56.5±15

** Race was self-declared; ** EuroSCORE II- European System for Cardiac Operative Risk Evaluation; *** STS- Society of Thoracic Surgeons.*

Variables referring to the intraoperative period are presented in table 2. Combined surgeries were performed in 17% of the cases. Five patients (2%) required intra-aortic balloon pump insertion and two patients died during surgery (0.7%), one due to acute myocardial infarction in a coronary artery bypass grafting (CABG) and the other to hyperacute rejection in a heart transplant.

Table 2. *Intraoperative characteristics and early postoperative outcomes.*

Intraoperative variables	N=271
Combined surgery – n (%)	47 (17)
Type of surgery – n (%)	
Coronary artery bypass grafting	145 (53)
Aortic surgery	24 (9)
Valve surgery	111 (41)
Heart transplant	11 (4)
Surgery duration – min.	
Median	180
Interquartile range	150-225
Extracorporeal circulation time – min.	
Median	73
Interquartile range	59-96
Ischemia time – min.	
Median	56.5
Interquartile range	45-76
Early postoperative outcomes	
Mechanical ventilation time – hours	
Median	7.5
Interquartile range	5-12
New atrial fibrillation – n (%)	61 (22.5)
Permanent pacemaker – n (%)	1 (0.4)
Bronchopneumonia – n (%)	29 (10.7)
Acute renal failure – n (%)	27 (10)
Increased chronic renal failure – n (%)	11 (4.06)
Stroke – n (%)	14 (5)
Delirium – n (%)	28 (10.3)
Acute myocardial infarction – n (%)	4 (1.5)
Length of stay in intensive care unit – days	
Median	3
Interquartile range	3-5
Total hospital stay time – days	
Median	7
Interquartile range	7-11

Table 2 also shows the main early postoperative complications. Prolonged mechanical ventilation (MV) time (≥24 hours) was observed in 10.2% of the patients and prolonged ICU stay (≥72 hours) in 44.5%. During the ICU period, ten deaths (3.7%) were recorded, three of them due to cardiogenic shock, three to septic shock, and two to mixed shock, besides one caused by stroke and one by multiple organ failure.

Seven additional deaths occurred after ICU discharge, totaling 19 deaths (7%). Analyzing the mortality rate per year, in 2015, 102 patients were enrolled and 11 deaths were recorded (10.8%), while, in 2016, 149 patients were enrolled and six deaths were registered (4%) (p=0.042). This finding remained statistically significant in a multivariate logistic regression model, even after adjusting for possible confounding variables, such as age, gender, urgency or emergency surgery, previous cardiac surgery, chronic renal failure, and extracorporeal circulation time (adjusted odds ratio =0.28; 95% confidence interval: 0.08-0.9; p=0.047).

The median length of hospital stay was seven days and 73 patients (27%) had prolonged hospital stay (≥10 days).

DISCUSSION

For nearly three decades, cardiovascular surgery has been a leader in clinical data records, risk-adjusted performance measurement, and data-driven quality improvement[11]. Adapting to this worldwide trend was imperative and urgent. However, adherence to universally-diffused databases, such as STS database, presented important limitations, especially financial ones, because it demanded payment of high charges, impracticable for developing or underdeveloped countries. In addition, their extensive and complex forms usually make it difficult to implement them in smaller surgery services, with no consolidated structure for data collection. In these services, surgeons themselves are involved in the data collection process and, therefore, do not have so much time to spend doing this task.

Similar limitations were found when analyzing the American College of Surgeons National Surgical Quality Improvement Program. Despite being a risk-adjusted and result-based program, with national validity and capacity to provide important reductions in surgical complication rates and deaths (according to the organizers, each year a hospital participates in the program, from 250 to 500 surgical complications are prevented and from 12 to 36 lives, saved), this tool, besides being paid, cannot be customized to the local demands and particularities of each center[12].

In view of these difficulties, as well as the lack of well-developed and consolidated strategies for collecting and storing surgical data in developing countries, we had the idea of developing a modern, widely-accessible, free, and reproducible platform, initially customized to cardiovascular surgery, but applicable to any surgical subspecialty.

For the main objective of this work - the elaboration and implementation of a cardiovascular surgery database -, we obtained full success, with excellent adhesion rate and filling maintenance. Being a fully electronic process, there was no need for paper forms, saving financial and environmental resources. It also facilitated the handling and future extraction of data, avoiding problems with readability or loss of forms.

Another benefit of the initiative was the, practically in real time, knowledge of local statistics, allowing more reliable preoperative advice, based on local results, for a population with similar characteristics and managements, instead of trying to import results from first-world countries, with different technologies, routines, and population characteristics compared to those found in our environment.

Likewise, it enabled the institution to identify areas for the creation of surgical quality improvement programs and resource investment, as well as to compare results to standards presented in national and international literature.

In terms of preliminary results, during the initial three years of the initiative, we observed rates of postoperative outcomes similar to those reported in STS database 2017: new atrial fibrillation of 22.5% in our study *versus* 24 to 44% in STS; prolonged MV time of 10% *versus* 5.3 to 29%; acute renal failure of 10% *versus* 1.1 to 8.2%; stroke of 5% *versus* 1.3 to 3.3%; and median length of hospital stay of seven days versus five to nine days[9].

Still according to STS database 2017, mortality rates in cardiovascular surgery can range from as high as 9.8% in combined mitral valve replacement surgery and CABG to as low as 1.1% in isolated mitral repair[9], values that cover the general rate of 7% observed in our study, including non-elective procedures.

Analyzing mortality rates for the first two years of the initiative, we clearly perceived a significant reduction after program implementation: from 10.8% in the first year to 4% in the second year. Some facts that could explain this finding are: 1) After the project implementation, service providers had access to result statistics and, thus, they were able to better understand factors related to adverse events and to improve the quality of the assistance offered; 2) Individual statistics served as an important motivational factor, not only for filling maintenance, but also for the search for constant scientific and technical improvement; 3) Profile identification of patients with higher surgical risk led to more in-depth discussions of surgical indication and even contraindication in case of unacceptable risks, as well as to the elaboration of specific assistance protocols for high-risk patient management.

In this sense, mortality reductions subsequent to the creation of data platform and establishment of quality improvement programs have consistently been proven by several researchers. Stamou *et al*., for example, have observed a mortality reduction from 5% to 2.6% (adjusted risk odds ratio =0.6, $p<0.01$)[4]. Likewise, Kogan *et al*. have divided 4866 patients undergoing cardiovascular surgery into three observation periods: I- before implementing a quality improvement program; II- after implementation; III- with the program already fully implemented, showing a decrease in unadjusted mortality from 6.37% in period I to 4.32% and 3.3% in periods II and III, respectively ($p<0.01$)[13]. In 2016, Cohen *et al*. reported significant improvements in long-term surgical outcomes after the establishment of the American College of Surgeons National Surgical Quality Improvement Program. Data from 2006 to 2013 were used to create models for predicting mortality, morbidity, and surgical site infection. In general, 62%, 70%, and 65% of the hospitals achieved reductions in mortality, morbidity, and surgical site infection, respectively, after adhering to the program[6].

The development of a fully electronic, customized, easy-to-build, and easy-to-fill database, based on Google tools, proved to be fully feasible and effective. In our initial experience in the field of cardiovascular surgery, we obtained a 100% inclusion rate of patients operated in the evaluated period, without loss of any variable. Periodic meetings for analysis and discussion of results kept the necessary motivation for the follow-up of the project, as well as made possible the early observation of adverse events and the subsequent adoption of appropriate measures.

The fact that it is a simple, intuitive, free, and widely accessible platform makes this strategy a possible model to be used as a basis for other surgical centers and specialties that wish to develop their own databases and, subsequently, surgical quality improvement programs based on success rates and local complications, becoming a valuable tool, especially for hospitals that do not have many financial resources.

R E S U M O

Objetivo: *descrever de maneira prática e detalhada a criação de uma plataforma totalmente informatizada para coleta, armazenamento e análise de dados, inicialmente proposta para cirurgia cardiovascular, com interfaces reprodutíveis e aplicáveis a outras especialidades cirúrgicas, bem como, apresentar a experiência inicial de trabalho com esta ferramenta e os resultados preliminares obtidos após sua implementação em um hospital universitário terciário brasileiro.* **Métodos:** *a plataforma foi desenvolvida com base nas ferramentas Google, gratuitas, de fácil utilização e amplamente acessíveis. Desde o início desta iniciativa, em maio de 2015, até a análise preliminar, em fevereiro de 2017, dados de 271 pacientes, consecutivos, submetidos à cirurgia cardiovascular foram prospectivamente recordados e analisados.* **Resultados:** *a iniciativa foi implementada com pleno sucesso, com 100% dos pacientes incluídos e sem perda de qualquer variável em um banco de dados composto por mais de 500 variáveis. As complicações pós-operatórias imediatas mais frequentes foram: fibrilação atrial (22,5%), broncopneumonia (10,7%), delirium (10,3%), insuficiência renal aguda (10%), acidente vascular encefálico (5%) e morte (7%). Comparando-se as taxas de mortalidade no primeiro e segundo anos da iniciativa, uma redução de 10,8% para 4% (p=0,042), respectivamente, foi evidenciada.* **Conclusão:** *a nova proposta de coleta e armazenamento de dados apresentada neste trabalho mostrou-se plenamente factível e efetiva. Por serem gratuitas, de fácil manuseio e universalmente acessíveis, estas ferramentas podem ser úteis a outras especialidades cirúrgicas que desejem desenvolver métodos de avaliação de sucesso e complicações pós-operatórios, bem como, programas de melhoria de qualidade.*

Descritores: *Procedimentos Cirúrgicos Cardiovasculares. Base de Dados. Educação. Qualidade da Assistência à Saúde.*

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