Rev Bras Cir Cardiovasc 2009; 24(3): 382-390

Identification of a statistical method as a quality tool: patient's length of stay in the operating room

Identificação de um método estatístico como instrumento da qualidade: tempo da presença do doente na sala de operação

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RBCCV 44205-1104

Abstract

Objective: **To identify a statistical method that may express the patient length of stay in the operating room and build a "matrix of relationship" for optimizing this time, the real and exact time of the operation.**

Methods: **The analysis of survival and the Kaplan-Meier estimator allowed to calculate the survival curves for different times and the "matrix of relationship" with 10 hypothesis to help in choosing the new operation. The study consisted of a simple random sample of 71 patients, from elective operations for adults in Cardiac Surgery/Clinics Hospital/Unicamp, with confidence level of 95% in 2008.**

Results: **On average, the times of the operations over at a range of 140 minutes to 200 minutes and excess from 5 minutes to 90 minutes. In general, on average, one operation was daily performed within 520 minutes, for a time of 720 minutes.**

Conclusion: **1) With the maximum available time of 720 minutes is not possible to perform surgery, unless using the "matrix of relationship", whereas the maximum time available varies between 660 minutes and 690 minutes, considering the range of cleaning of the room. 2) The time of the patient in the operating room is a time that includes the time of learning by the student in an university hospital school. 3) When optimizing the time, most patients will benefit, causing a decrease from the waiting list for new opeartions. 4) The "matrix of relationship" allows to view and express opinion on a better decision making in addition to decide upon several assumptions.**

Descriptors: **Cardiac surgical procedures. Survival analysis. Quality Control.**

Resumo

Objetivo: **Identificar um método estatístico que expresse o tempo da presença do doente na sala de operação e construir a "matriz de relação" de otimização deste tempo, o tempo exato e real da operação.**

Métodos: **A análise de sobrevivência e o estimador de Kaplan-Meier permitiram calcular as curvas de sobrevivência para os diferentes tempos e a "matriz de relação" com 10 hipóteses para auxiliar na escolha da nova operação. A amostra aleatória simples de 71 indivíduos, das operações eletivas de adultos da Cirurgia Cardíaca/Hospital de Clínicas/UNICAMP, no ano 2008, no nível de confiança de 95%.**

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Article received on May 1st, 2009
Article accepted on July 20th, 2009

Resultados: **Os tempos das operações em média sobram em um intervalo de 140 a 200 minutos e excedem de 5 a 90 minutos. No geral, realizou-se em média diariamente uma operação dentro de 520 minutos, para um tempo disponível de 720 minutos.**

Conclusão: **1) Com o tempo máximo disponível de 720 minutos não é possível realizar operação, a não ser utilizando da "matriz de relação", sendo que o tempo máximo disponível varia entre 660 e 690 minutos, considerando-se intervalo de limpeza da sala. 2) O tempo do doente na sala de operação tem nele incluso o tempo de aprendizado pelo aluno, em um hospital escola, universitário. 3) Ao otimizar o tempo, mais doentes serão beneficiados, acarretando diminuição da fila de espera para novas operações. 4) A "matriz" de relação permite visualizar, opinar e decidir mediante várias hipóteses, resultando em melhor tomada de decisão.**

Descritores: **Procedimentos cirúrgicos cardíacos. Análise de sobrevida. Gestão de qualidade.**

INTRODUCTION

The constitutional principles of the Health Care System (SUS) together with the Brazilian nosological situation and technological evolution and increase of its costs, as a result of scientific progress, make the prioritization of health interventions a critical issue. Citing Fourez [1], "For many of our contemporaries, it seems clear that science and technology are connected". According Bittar [2], citing Sloan and Valcona, "the more precise and rapid diagnosis - due to the development of complementary services - have brought, as a result, a decrease in length of stay. Also, one should not forget the technological development occurred with drugs, orthoses, prostheses and procedures that directly influence on the length of stay required for recovery of patients".

Hospital processes constantly need to be improved. The search for tools that can measure the processes and activities, make possible the improvement of the quality of services provided. Combined with a high-technology, professionals who always are well prepared for the management of such services, are an important factor in the relationship of medical care with patients, as well as the time the procedures are performed is an essential variable to be measured - from the waiting list of the patient to be treated up to his effective treatment. As a result we can mention the effective and efficient use of resources, indicators measuring the quality and quantity of what is done in terms of programs and health services, such as structure, processes and outcomes; by avoiding waste, such as cancellation of surgeries, time in waiting list, among others that should be pursued by the manager, otherwise the Hospital not may survive. Such subjects are approached by Aranha [3], Bittar [4], Duarte and Ferreira [5], Perroca et al. [6] and Haddad et al. [7].

The aim of this study is to identify a statistical method that expresses the time of the presence of the patient in the operating room and build a relationship matrix of optimization of this time, the exact and real time of the operation.

METHODS

The research on the literature guided to a path that could approach the improvement in the optimization and quality of service. In this study we applied the method of survival analysis to assess the times: Real Time of Surgery (T1), the Exact Time of Surgery (T2) and Time of the Presence of the Patient in the Operating Room (T3). The classification of heart surgeries is in Chart 1 and are part of this study of the times T1, T2 and T3.

Chart 1. Heart surgery procedures

Name	Code
Mitral – bioprosthesis replacement	1
Mitral – mechanical prosthesis replacement	1
In-patient implant of valve prosthesis (valve repair)	1
Aortic – bioprosthesis replacement	1
Aortic – mechanical prosthesis replacement	1
On-pump CABG surgery	3
Valve replacement with CABG	3
Interatrial communication closure	2
Enlargement of the right ventricular outflow tract and/or pulmonary branches	2
Correction of total anomalous drainage of the pulmonary veins	2
Correction of double-outlet right ventricle	1
Aortic root repair using valvulated tube	4
Descending aortic replacement	4
Ascending aortic replacement	4
Pericardiectomy	5
Surgical debridment	5
Valve prosthesis implant	1

Codes: 1) Valvar – 2) Congenital heart diseases – 3) Ischemic heart disease – 4) Aortic aneurysm – 5) Other procedures: Pericardiectomy and Surgical debridement

After classifying the times of operating room and the types of operation, we identified the schedule of the operating room for heart surgery, which has an exclusive room, with two periods of 360 minutes, totaling 720 minutes available daily. Next, we used the method of applied survival analysis, according to Colosimo and Giolo [8], which seemed to be the most appropriate for this type of study. The records collected came from a random sample of 71 patients, whereas eight of aortic aneurysm, six of ischemic heart disease, six with congenital heart disease, two of other procedures (pericardiectomy and surgical debridement) and 49 valve disease patients, at a confidence level of 95% during the year 2008, noting that at the time of collection of this sample there was no aortic surgery. The data are only related to adult patients undergone heart surgeries at the mentioned period and were performed at the Clinics Hospital of UNICAMP, and the software used for analysis was the SAS.

In survival analysis, the dependent variable is the time when the event occurs, or that is, when the surgery is performed. This time is counted from the time of entry into the operating room, which is the "time of entry into the operating room" until the discharge from the operating room, which is the "time of discharge from the operating room". The dependent variable, time, is the "failure time", that in this case, is the time when the surgery was not accomplished and it refers to the initial time, the measurement scale and the occurrence of the event. The aim of this statistical analysis is to identify factors that may influence the processing time. The time in which the event of interest occurs is specified by its "survival function" or "risk function". The first is the probability that an observation does not fail until a specified time. The second is the probability that the failure occurs in a period of time. The procedure adopted is to find an estimate for the survival function and, from such function, to estimate these measures.

The most widely known technique for this purpose is the Kaplan-Meier nonparametric method, where: S (t) = number of observations that have not failed until a specified time/ total number of observations in the study. The estimator considers both time intervals as the number of distinct failures. To assess the accuracy of this estimator it can be built confidence intervals and hypothesis test for S (t). The survival curves for this study and further analysis were calculated for: T1 - Real Time of Surgery, T2 - Exact Time of Surgery and T3 - Time of the Presence of the Patient in the operating room. The data collected do not have any missing time, and there is therefore no variable without values.

RESULTS AND DISCUSSION

Surgeries and cardiac hospital stay are shown in the Table 1.

Table 1. Performed surgeries and hospital stay

Specifications for Daily Mean	Total	Mean
Elective	365	2
-- Adults	291	1
-- Infant	74	1
Urgency/Emergency	193	1
-- Adults	181	1
-- Infant	12	0
Cancelled	236	1

Source: Surgical Center/HC/UNICAMP

Note: Elective surgeries from adult patients were performed within 203 days and infant ones 72. Urgency/Emergency surgeries were performed within 181 days

Regarding the cancellation of surgeries, there were many different reasons, such as administrative reasons or "extra-patient hospital factors", 190 surgeries suspended; reasons related to patients, 46 surgeries suspended, totaling 236 surgeries suspended; and two reasons mainly due to "inadequate surgical time", 92 suspended surgeries; and "lack of beds available", 70 suspended surgeries, totaling 162 suspended surgeries due to the maximum time available for daily surgeries at the Surgical Center, which could be better controlled, reducing the waiting list.

Survival analysis for time (minutes) T1, T2 and T3, in general and in particular by type of surgery

T1 (end time of the surgery - time of anesthetic induction) - Real-Time of Surgery, T2 (end time of the surgery - time of (degermation + assepsy + placement of surgical fields)) - Exact Time of Surgery and T3 (time of discharge from the operation room - time of entry into the operating room) - Time of the Presence of the Patient in the Operating Room, presented with their respective graphics.

Survival analysis - times T1, T2 and T3 (General)

- Time (T1) - Real Time of Surgery (minutes). By the time 290 minutes, in about 49% of surgeries their T1 time was not completed, and so until the time of 485 minutes on average all surgeries in general had their T1 time completed (Fig. 1).

- Time (T2) - Exact time of Surgery (minutes). By the time 265 minutes, in about 51% of surgeries their T2 times were not completed, and so until the time of 420 minutes on average, all surgeries had their T2 time completed (Fig. 2).

- Time (T3) - Time of the Presence of the Patient in the Operating Room (minutes). By the time of 340 minutes, in about 51% of surgeries their T3 times were not completed, and so until the time of 520 minutes on average, all surgeries had their T3 completed (Fig. 3).

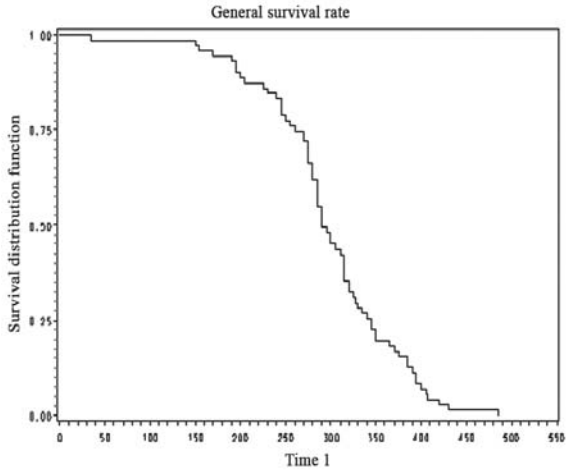

Fig. 1 - General survival rate – time 1: T1 - Real Time of Surgery (minutes)

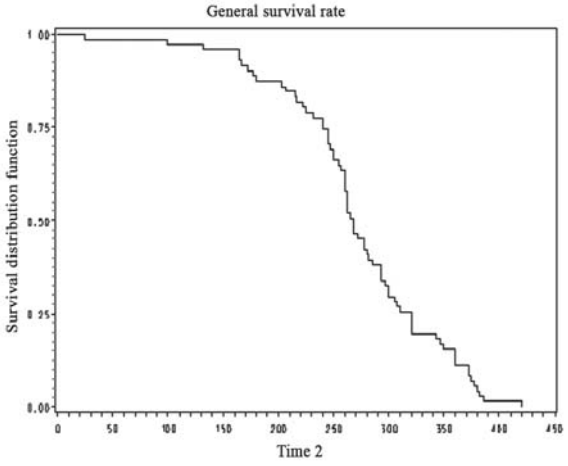

Fig. 2 - General survival rate – time 2: T2 - Exact Time of Surgery (minutes)

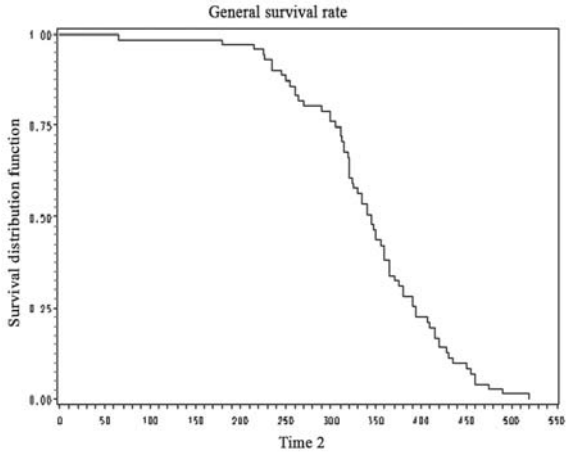

Fig. 3 - General survival rate - time 3; T3 - Time of the Presence of the Patient in the Operating Room (minutes)

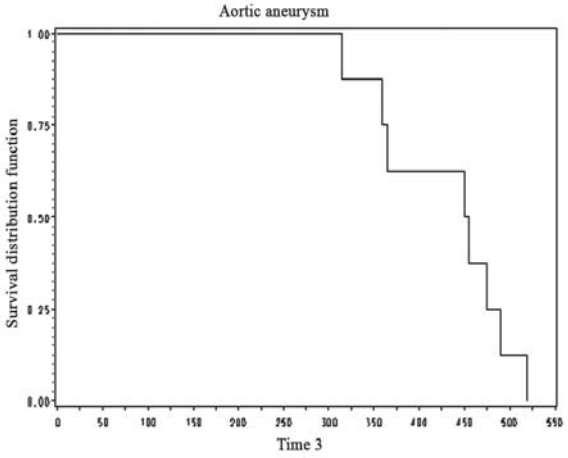

Fig. 4 - Type survival rate: Aortic aneurysm - time 3: T3 -Time of the Presence of the Patient in the Operating Room (minutes)

Survival analysis - time T1, T2 and T3 - by types of heart surgery

Aortic aneurysm

- Time (T1) - Real Time of Surgery (minutes). By the time of 350 minutes, in about 50% of surgeries their T1 times were not completed, and so until the time of 485 minutes on average all surgeries had their T1 times completed.

- Time (T2) - Exact time of Surgery (minutes). By the time of 320 minutes, in about 50% of surgeries their T2 times were not completed, and so until the time of 420 minutes on average, all surgeries had their T2 times completed.

- Time (T3) - Time of the Presence of the Patient in the Operating Room (minutes). By the time of 450 minutes, in about 50% of surgeries their T3 times were not completed, and so until the time of 520 minutes on average, all surgeries had their T3 times completed (Fig.4).

Ischemic heart disease

- Time (T1) - Real Time of Surgery (minutes). By the time of 275 minutes, in about 50% of surgeries their T1 times were not completed, and so until the time of 400 minutes on average, all surgeries had their T1 times completed.

- Time (T2) - Exact time of Surgery (minutes). By the time of 250 minutes, in about 50% of surgeries their T2 times were not completed, and so until the time of 377 minutes on average, all surgeries had their T2 times completed.

- Time (T3) - Time of the Presence of the Patient in the Operating Room (minutes). By the time of 340 minutes, in about 50% of surgeries their T3 times were not completed, so until the time of 420 minutes on average, all surgeries had their T3 times completed (Fig. 5).

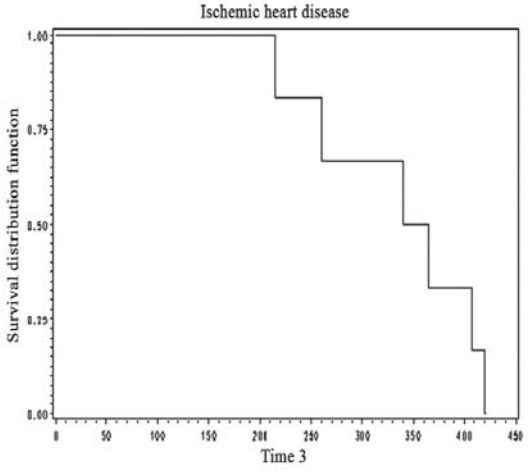

Fig. 5 -Type survival rate: Ischemic heart disease - time 3: T3 - Time of the Presence of the Patient in the Operating Room (minutes)

Congenital heart disease

- Time (T1) - Real Time of Surgery (in minutes/hours). By the time of 245 minutes, in about 50% of surgeries their T1 times were not completed, and so until the time of 285 minutes on average, all surgeries had their T1 times completed.

- Time (T2) - Exact Time of the Surgery (in minutes). By the time of 222 minutes, in about 50% of surgeries their T2 times were not completed, and so until the time of 262 minutes on average, all surgeries had their T2 times completed.

- Time (T3) - Time of the Presence of the Patient in the Operating Room (in minutes). By the time of 270 minutes, in about 50% of surgeries their T1 times were not completed, and so until the time of 355 minutes on average, all surgeries had their T3 times completed (Fig. 6).

Valve diseases

- Time (T1) - Real Time of Surgery (minutes). By the time of 290 minutes, in about 51% of surgeries their T1 times were not completed, and so until the time of 408 minutes on average, all surgeries had their T1 times completed.

- Time (T2) - Exact Time of Surgery (minutes). By the time of 265 minutes, in about 53% of surgeries their T2 times were not completed, and so until the time of 385 minutes on average, all surgeries had their T2 times completed.

- Time (T3) - Time of the Presence of the Patient in the Operating Room (minutes). By the time of 340 minutes, in about 51% of surgeries their T3 times were not completed, so until the time of 460 minutes on average, all surgeries had their T3 times completed (Fig. 7).

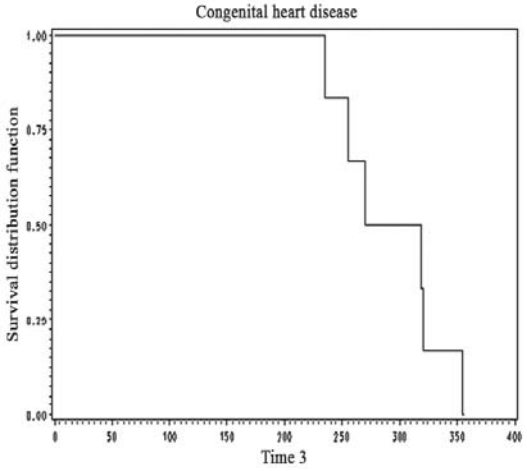

Fig. 6 - Type survival rate: Congenital heart disease - time 3: T3 - Time of the Presence of the Patient in the Operating Room (minutes)

Other procedures: pericardiectomy and surgical debridement

- Time (T1) - Real Time of Surgery (minutes). By the time of 190 minutes, in about 50% of surgeries their T1 were not completed, and so until the time of 250 minutes on average, all surgeries had their T1 times completed.

- Time (T2) - Exact Time of Surgery (minutes). By the time of 167 minutes, in about 50% of surgeries their T2 times were not completed, and so until the time of 225 minutes on average, all surgeries had their T2 times completed.

- Time (T3) - Time of the Presence of the Patient in the Operating Room (minutes). By the time of 225 minutes, in about 50% of surgeries their T3 times were not completed, and so until the time of 310 minutes on average, all surgeries had their T3 times completed (Fig. 8).

Calculating the probability of surgeries using the survival analysis and buiding a "relationship matrix' for optimizing the time of the presence of the patient in the operating room (T3), it is shown in Chart 2 the main time limits in general and by specialty to: T1, T2 and T3, the maximum time available, the difference of these times between the T3 time and the difference between the maximum time available and the T3 considering the minimum

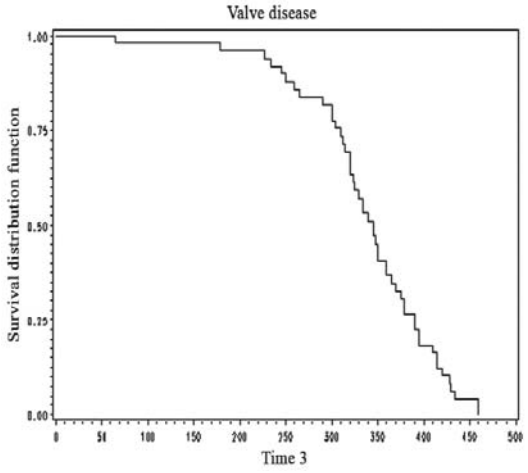

Fig. 7 - Type survival rate: Valve disease - time 3: T3 -Time of the Presence of the Patient in the Operating Room (minutes)

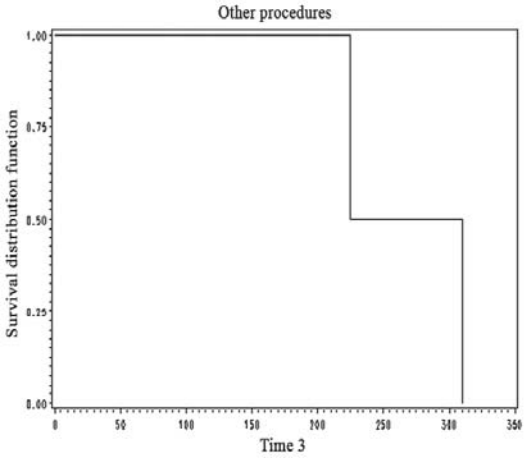

Fig. 8 - Type survival rate:Other procedures - time 3: T3 -Time of the Presence of the Patient in the Operating Room (minutes)

Chart 2. Maximum time in the operating room (minutes) – T1: Real Time of Surgery – T2: Exact Time of Surgery – T3: Time of Presence of the Patient in the Operating Room

Maximum time (minutes)	General	Aneurysm	Valvar	Ischemic heart disease	Congenital heart disease	Other procedures
Time in the operating room						
T3	520	520	460	420	355	310
T2	420	420	385	377	262	225
T1	485	485	408	400	285	250
Available maximum times (TMax)						
TMax (720 minutes)	720	720	720	720	720	720
T Max (660 minutes) (- 60 minutes - assepsy)	660	660	660	660	660	660
TMax (690 minutes) (- 30 minutes - assepsy)	690	690	690	690	690	690
TMax (720 minutes)-minimum for assepsy	710	695	710	695	710	670
Tmax (720 minutes)-maximum for assepsy	660	665	680	660	710	670
Difference = TMax (720)- T3 (H1 and H2)	200	200	260	300	365	410
Difference = TMax (660)- T3 (H3 and H4)	140	140	200	240	305	350
Difference = TMax (690)-T3 = (H5 and H6)	170	170	230	270	335	380
Difference = TMax (720)-T3 TLMax type (H7 and H8)	140	145	220	240	355	360
Diference = TMax (720)-T3 TLMin type (H9 and H10)	190	175	250	275	355	360
Time of assepsy of the operating room						
Minimum assepsy time (TLMin)	10	25	10	25	10	50
Maximum assepsy time (TLMax)	60	55	40	60	10	50
Time of assepsy according the literature (approximately)	30	30	30	30	30	30
Time of use of the Operating Room						
-- Minimum time of use = T3 +TLMin	530	545	470	445	365	360
-- Maximum time of use = T3 +TLMax	580	575	500	480	365	360

and maximum times of assepsy according the type of surgery and the assepsy time described in the literature, according Nepote [9]. In Chart 3, the "relationship matrix" is a cross-analysis of informations obtained by the survival analysis and contains the difference of maximum times with respect to T3, the 10 hypotheses aiding in re-operation, spare time and over time of the possible new surgeries, and, in general and in the average, the spare time is of 140 minutes to 200 minutes, and over time of 5 minutes to 90 minutes and no new surgery to be performed. For example, if it is used H1, Tmax difference (12)-T3 (=200) and considering the rule of H1: "performing another surgery of the same type", it seems that another surgery of aortic aneurysm, which uses an average of 520 minutes, is not possible. Since it spares 200 minutes (720 - 520 = 200), it is not possible to perform another surgery of the same type, and does so with the other cases in accordance with its rules and the maximum available time at the Surgical Center, and one should also consider that the assepsy time of the operating room should vary from 10 minutes to 60 minutes according to the assepsy time for each type of surgery. It was established as a rule in this study, a possibility of exceeding the time for new surgeries in up to 90 minutes.

Chart 3. Matrix of relationship of optimization of the patients stay time in the operating room

Types		Surgeries x Remaining/Over time in relation to Available Times					
Times Analysis Survival (T3)		General 520	Aneurysm 520	Valvar (Val) 460	Congenital (Cong) 355	Ischemic (Isc) 420	Other Procedures (OP) 310
Hypothesis	General available time (minutes)	Remainig time (minutes)/over time (minutes)					
		General	Aneurysm	Valvar	Congenital	Ischemic	OP
H1	720	200 r (200): nr	200 r (200):nr	260 r (260):nr	365 r (10):Cong	300 r(300):nr	410 r(100):OP
H2	720	200 r (200): nr	200 r (200):nr	260 o (50):OP	365 r (55):OP o (55); Isq	300 o(55):Cong o(10): OP	410 o(50):Val o(10):Isc r(55):Cong
H3	660	140 r (140):nr	140 r (140):nr	200 r (200):nr	305 r(305):nr o(50):Cong	240 r(240):nr	350 r(40):OP
H4	660	140 r (140):nr	140 r (140):nr	200 r (200):nr	305 o(5):OP	240 o(70):OP	350 o(5):Cong o(70): Isc
H5	690	170 r (170):nr	170 r (170):nr	230 r (230):nr	335 o(20):Cong	270 r(270):nr	380 r(70):OP
H6	690	170 r (170):nr	170 r (170):nr	230 o (80):OP	335 r(25):OP o(85):Isc	270 o(40):OP o(85):Cong	380 r(25):Cong o(40):Isc o(80):Val
H7	660	140 r (140):nr	145 r (145):nr	220 r (220):nr	355 r(0):Cong	240 r(240):nr	360 r(50):OP
H8	660	140 r (140):nr	145 r (140):nr	220 o (90): OP	355 r(45):OP o(65):Isc	240 o(70):OP	360 r(5):Cong o(60):Isc
H9	710	190 r (190):nr	175 r (175):nr	250 r (250):nr	355 r(0):Cong	275 r(275):nr	360 r(50):OP
H10	710	190 r (190):nr	175 r (175):nr	250 o (60):OP	355 r(45):OP o(65):Isc	275 o(35):OP o(80):Cong	360 r(5):Cong o(60):Isc

Note 1: General mean of remaining time from 140 minutes to 200 minutes – and mean of Over Time from 5 minutes to 90 minutes. Note 2: r: remaining time, o: over time and nr: no new surgery to be performed

Assumptions for performing of new surgery of the same type or not, for each type of heart surgery:

H1: New Surgeries of the same type, with Tmax Difference = (720)-T3;

H2: New Surgeries of different types, with Tmax Difference = (720)-T3;

H3: New Surgeries of the same type, with Tmax Difference = (660)-T3;

H4: New Surgeries of different types, with Tmax Difference = (660)-T3;

H5: New Surgeries of the same type, with Tmax Difference = (690)-T3;

H6: New Surgeries of different types, with Tmax Difference = (690)-T3;

H7: New Surgeries of the same type, with Tmax Difference = (720)-T3 TLMax type;

H8: New Surgeries of different types, with Tmax Difference = (720)-T3 TLMax type;

H9: New Surgeries of the same type, with Tmax Difference = (720)-T3 TLMin type;

H10: New Surgeries of different types, Difference Tmax = (12)-T3 TLMin type (Chart 4).

Analyzing the possibilities for performing new surgeries with respect to the 10 hypotheses, we can mention: H10: seven possibilities, H2 and H6: eight possibilities, H8: five possibilities, H4: four possibilities: H1, H3, H5, H7, H9: two possibilities, depending on the end average time of surgery, type of surgery, with an interval of time plus 90 minutes to perform new surgeries, assepsy of the operating room between surgeries, and according to the hypothesis adopted, it may be an increase in quantity and better planning of surgeries, reduction of waiting list, cost of the operating room, and therefore social benefit. It is expected an increase in a daily surgery, except for aortic aneurysm, due to the time of this procedure is of 520 minutes on average.

Operating Room. In general, the mean time in minutes is as follows: for T1, Real Time of Surgery, 298 minutes; T2, Exact Time of Surgery, 271 minutes; and T3, Time of the Presence of the Patient in the Operating Room, 342 minutes. Suspention of Surgeries: If there was no suspension of surgeries due to administrative reasons, 481 surgeries could be performed. In general, the monthly average of surgeries would probably be 40 surgeries or 10 surgeries weekly or two daily surgeries, except when it is aortic aneurysm surgery, which has a maximum time of 520 minutes, but mainly one should be considered the possibilities of relationship matrix for optimization of time of the patient in the operating room for decision making.

Duarte & Ferreira [5] identified as an important indicator of process, surgeries suspended due to extra-patient hospital factors, that has been used to reveal the degree of organization of the Surgical Center, as well as the surgery of various units of the hospital, because it involves the monitoring of various processes and subprocesses. The follow-up and correction of the main causes of hospital suspension of the surgery can lead to reductions in waste, increased quality and productivity, in agreement with this study, on which the suspension causes several "wastes", an indicator that already was studied by Aranha and Vieira [10].

According Perroca et al. [6] with respect to cancellations of surgeries, it is estimated that about 60% of cancellations of elective procedures are potentially avoidable and could be prevented by using techniques of quality improvement. Haddad et al. [7] performed a research on patientes candidates for heart surgery, on which the objective was to assess mortality and the psychological repercussions of the prolonged waiting time for such patients eligible for heart surgery. The results showed that several patients presented severe anxiety and they attributed the problems of adaptation - in the context of their emotional, social and professional life – to the non-surgical treatment. According Bittar [4], it is unnecessary to emphasize the importance of indicators that measure the quality and quantity of what is done in terms of programs and health services and that they cover all of its components, such as structure, processes and results.

Chart 4. Planning of the optimization of the heart surgery room with prediction of new surgeries

Types	Tipos				
	Aneurysm	Valvar	Ischemic heart disease	Congenital heart disease	Other procedures
Aneurysm	—	—	—	—	—
Valvar	—	—	—	—	H2/H6/H10
Ischemic heart disease	—	—	—	H2/H6/H10	H2/H4/H6/H8/H10
Congenital heart disease	—	—	H2/H6/H8/H10	H1/H3/H5/H7/H9	H2/H4/H6/H8/H10
Other procedures	—	H2/H6	H2/H4/H6/H8/H10	H2/H4/H6/H8/H10	H1/H3/H5/H7/H9

CONCLUSION

In short, the method of survival analysis allows to cross informations and build step by step, the scientific and technological knowledge, resulting in a quality instrument, as is the "relationship matrix" for optimizing the time of the patient in the operating room, concluding that: 1) The time of the patient in the operating room is a time that includes the time of learning by the student in a teaching or university hospital. 2) With the maximum available time of 720 minutes is not possible to perform other daily surgery, except for predicting the average times of surgeries obtained by the analysis of survival and establishment of the "relationship matrix", as it became evident that the time is "not" 720 minutes daily and should be lower, due to the time of assepsy of the operating room between a surgery and another. 3) By optimizing the time of the patient in the operating room through the "relationship matrix" it will be chosen the hypothesis with better convenience, because it increases surgeries, allowing that the spare time of the previous surgery may be occupied, decreasing the waiting list.

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