

ORIGINAL ARTICLE

Correlation between Surgical Risk Scales with Respiratory Muscle Strength and Functional Independence in Patients Submitted to Coronary Artery Bypass Grafting

André Luiz Lisboa Cordeiro,^{1,2} Átila Darlan Queiroz de Brito,² Grazielle Freitas Almeida,² Leilane Souza Jesus,² Flávia de Araújo Oliveira,² Janinne Lima da Silva,² André Raimundo França Guimarães,³ Roberto Moreno Barros⁴

Escola Bahiana de Medicina e Saúde Pública,¹ Salvador, BA – Brazil.

Faculdade Nobre,² Feira de Santana, BA – Brazil.

Instituto Nobre de Cardiologia,³ Feira de Santana, BA – Brazil.

Hospital Santo Antônio,⁴ Hospital Santo Antônio, BA – Brazil.

Abstract

Background: The European Heart Surgery Risk Assessment System (EuroSCORE) and InsCor have been used to predict complications of cardiac surgery. However, their application to predict lung function and functionality is still uncertain.

Objective: To correlate surgical risk scales with functional independence and pulmonary function in patients undergoing coronary artery bypass grafting.

Methods: This was a prospective cohort study. In the preoperative period, the two surgical scales were applied, the maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), and peak expiratory flow (PEF) were measured, and functionality was assessed using the functional independence measure (FIM). On the seventh postoperative day, the pulmonary function and functionality variables were reevaluated, compared with the preoperative values (delta) and correlated with the risk scales. Correlations of pulmonary function, functional independence and muscle strength variables with the surgical scales were made by Pearson correlation test. The significance level adopted was 5%.

Results: Thirty-one patients were studied; most were male (77%), with a mean age of 56±8 years. Mean EuroSCORE was 2.3±0.5 and mean InsCOR was 1.2±0.5. MIP, MEP, and PEF reduced 30% (p<0.001), 33% (p<0.001) and 10% (p=0.23), respectively. The EuroSCORE correlated with MIP (r=0.78; p = 0.02) and FIM (r=0.79; p <0.01), and the InsCor correlated with MIP (r=0.77), MEP (r=0.73) and MIF (r=0.89; p=0.02).

Conclusion: The EuroSCORE showed a strong negative correlation with MIP and FIM, while InsCor had a strong negative correlation with MIP, MEP and FIM. (Int J Cardiovasc Sci. 2020; [online].ahead print, PP.0-0)

Keywords: Cardiovascular Diseases/mortality; Risk Assessment; Myocardial Revascularization; Pre-Operative Care; Postoperative Care; Respiratory Pressures; Physical Therapy Speciality; Muscle Strength.

Introduction

Cardiovascular diseases are the leading cause of death in the world. In Brazil, they represent about 30% of the number of deaths. Coronary artery bypass grafting (CABG) is the most common surgical procedure used to treat coronary heart disease, with a high probability of improving ventricular

function, reducing symptoms and improving patients' prognosis.¹ The main complications of CABG are related to comorbidities that affect respiratory function, such as chronic obstructive pulmonary disease, pulmonary congestion and prolonged mechanical ventilation, in addition to systemic infections, diabetes mellitus, renal failure and hemodynamic stability.^{1,2}

Mailing Address: André Luiz Lisboa Cordeiro

Escola Bahiana de Medicina e Saúde Pública

Av. Dom João VI, 275. Postal Code: 40050-420, Brotas, Salvador, BA – Brazil.

E-mail: andreliisboacordeiro@gmail.com

Functionality may be altered in patients undergoing myocardial revascularization, due to the immobility and complexity of the procedure, such as degree of sedation, cardiopulmonary bypass (CPB), preoperative pulmonary and cardiac functions and mobility restriction in case of admission to the intensive care unit (ICU).^{2,3}

Risk scales such as the European System for Cardiac Operative Risk Evaluation (EuroSCORE) and the InsCor in cardiac surgeries are shown to be simple and objective indices to predict operative mortality. In both scores, the preoperative evaluation offers the advantage of patients' stratification, allowing better intraoperative and postoperative planning, with similar performance and accuracy. However, these scores do not provide information about pulmonary function, since the EuroSCORE only evaluates previous chronic lung diseases and pulmonary hypertension, and the InsCor does not provide pulmonary function indices.⁴⁻⁷

The functional independence measure (FIM) is a measurement tool used that can be used in these patients to assess functionality, analyzing some of its aspects including self-care, sphincter control, locomotion, cognition, bed transfer and communication.⁸

In addition, to obtain effective treatment, a careful and efficient preoperative evaluation is essential, analyzing patient's pulmonary function, considering the tendency decreased lung volumes and capacities. It is also important to pay attention to possible risks and complications, and properly advise the patient about the procedure, including the extubation process.⁹

Although these scales are validated, there is still no evidence on their possible use to predict the worsening of peripheral and respiratory muscle strength, functionality and pulmonary function of the patient. This would allow the use of these two scales in the preoperative period to identify individuals who would need different care, becoming a tool for individualization of care. The present study aims to correlate surgical risk scales with functional independence measure (FIM) and pulmonary function parameters in patients undergoing CABG.

Material and Methods

This was a prospective cohort study conducted from January 2018 to April 2019, at the intensive care unit (ICU) of Instituto Nobre de Cardiologia, a referral center for cardiovascular care in the City of Feira de Santana, state of Bahia. This study was approved by the Research

Ethics Committee of Faculdade Nobre (approval number 2.490.540), and all participating patients signed an informed consent form.

Eligibility criteria

Adult patients of both sexes and over 18 years old, who underwent elective CABG surgery via sternotomy and cardiopulmonary bypass were included in the study. Exclusion criteria were patients with cognitive impairment or neurological and locomotor disorders, previous neurological disease, lower limb amputation (which could affect functionality and quality of life), those who stayed in the ICU for more than three days, readmission to the ICU prior to post-discharge evaluation, death, change in the surgical treatment plan, rescheduling of the date of the procedure and history of smoking or chronic lung disease. The reason for excluding patients who stayed more than three days in the ICU is that they could have had surgery-related complications and represent a bias for future data analysis.

Study protocol

Muscle strength of the patients was assessed preoperatively using the Medical Research Council (MRC) framework. Respiratory muscle strength and pulmonary function was assessed by measuring maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), and peak expiratory flow (PEF). The surgical risk was assessed using the EuroSCORE and InsCor. On the day after these tests, patients were referred to the operating room and subsequently to the ICU. During this period, they were managed according to standard practices of each department, including breathing exercises such as deep or sustained maximal inspiration, lying-to-sit transfer, active kinesiotherapy, orthostatic training, steady gait, ambulation and sitting in an armchair. When postoperative stability was achieved, patients were discharged from the ICU transferred to the wards, where they continued to be followed through the physical therapy protocol of the hospital.

On the seventh postoperative day, they were reassessed for MRC, FIM, MIP, MEP and PEF; the variation (delta) of these variables between the two moments was calculated and correlated with the surgical risk scales applied preoperatively.

Measuring instruments

FIM measured the ability of individuals to perform daily activities, as well as their cognitive ability. Activities related to personal care, sphincter control, mobility, communication, and social cognition were scored from 1 (total dependence) to 7 (complete independence), with a maximum value of 126 points.¹¹

The MRC scale tests muscular strength, with application of manual resistance on patient in dorsal, ventral, lateral and sitting positions. Both left and right sides are tested to reduce the influence of dominance and possible asymmetrical involvement of the muscle groups: shoulder abductors, elbow flexors, wrist extensors, hip flexors, knee flexors and ankle dorsiflexors. The MRC scale ranges from 0 to 5 where 0 indicates that there is no visible muscle contraction and 5 indicates a normal strength, with a maximum score of 60.¹²

For assessment of the MIP, using a mask, patients were instructed to breathe out completely (near the residual volume), followed by a maximal inspiration. To determine the MEP, a maximum expiration was performed using an analogue manovacuometer (Indumed®, São Paulo, Brazil). Three to six measurements were taken, avoiding variations of up to 10%, considering the highest value for analysis.¹³ PEF was assessed using a Mini Wright® peak flow meter; participants were asked to blow as vigorously as possible. Three to six trials were performed, with a pause of about 10 seconds between repetitions; values were measured in L/min.¹⁴

The EuroSCORE is a risk-stratification tool used to evaluate risk of death specifically after cardiac surgery. This scale was constructed based on data collected from 128 centers in eight European countries. It system evaluated 68 preoperative and 29 operative risk factors, that could influence hospital mortality. It also identified 17 real risk factors related to the patient, the heart, and the surgery itself. For each factor, in a univariate analysis, a score was assigned, classifying the patients into three groups, according to the risk obtained, *i.e.*, low, medium or high. It is an easy-to-use tool, and its web-accessibility has greatly contributed to the popularization of its use.¹⁵

The InsCor is a EuroSCORE-derived risk score that assesses local parameters and has flagged 10 risk factors related to patients undergoing cardiac surgery. Variables such as age around 70 years, female sex, myocardial revascularization with valve repair, recent infarction <90 days, reoperation, surgical treatment of

the aortic and tricuspid valves, creatinine > 2mg / dL, ejection fraction <30% and at least one of the following events prior to surgery: intra-aortic balloon, cardiogenic shock, tachycardia, ventricular fibrillation, orotracheal intubation, acute renal failure, inotropic drug use and cardiac massage.¹⁶

Data analysis

For data analysis, the SPSS 20.0 program was used. Normality was assessed by the Shapiro-Wilk test. Continuous data were expressed as mean and standard deviation and categorical data as absolute value and percentage. Pre- and postoperative values were evaluated by the paired Student's t-test. To correlate the values of pulmonary function, functional independence and muscle strength with the surgical scales, the Pearson test was used. This test was used due to the normality of the sample. The significance level adopted in the statistical analysis was 5%.

Results

Fifty-nine patients hospitalized for myocardial revascularization surgery were included in the study. Of these, 28 were excluded because of an ICU longer than three days (n=14), death (n=2), change in the surgical treatment plan (n=1), rescheduling of the date of the procedure (n=1), refusal to attend data collection (7th POD) (n=4) and patients discharged before the 7th POD (n=6) (Figure 1).

Therefore, 31 patients were evaluated, 24 (77%) male and with a mean age of 56 ± 8 years. Mean EuroSCORE was 2.3 ± 0.5 and mean InsCor score 1.2 ± 0.5 . Other clinical and surgical data are described in Table 1.

All variables related to respiratory muscle strength and pulmonary function was decreased on the seventh POD compared with the preoperative period. The MIP, the MEP and PEF reduced by 30%, 33% and 10%, respectively. In addition, we observed a decrease of 6% in FIM and 5% in MRC (Table 2).

When we correlated the delta of pulmonary function, functionality and peripheral muscle strength with the cardiac risk scales, we found that EuroSCORE had a strong negative correlation with MIP and FIM, while InsCor had a significant positive correlation with MIP, MEP and FIM (Table 3).

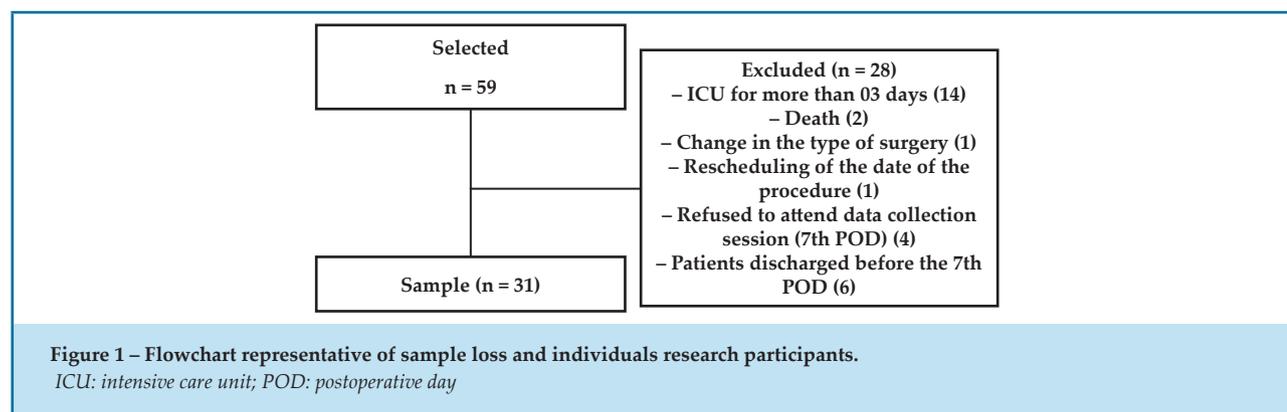


Table 1 – Clinical data of patients (n=31) undergoing coronary artery bypass grafting

Variables	Values (in number and percentage or mean and standard deviation)
Gender	
Male	24 (77%)
Female	7 (23%)
Age (years)	56 ± 8
BMI (kg/m ²)	27 ± 4
CPB time (min)	85 ± 10
MV time (hours)	6 ± 4
Number of drains	2.3 ± 0.4
Number of grafts	2.3 ± 0.5
EuroSCORE	2.3 ± 0.5
InsCor	1.2 ± 0.5

BMI: Body mass index; CPB: cardiopulmonary bypass; MV: mechanical ventilation; EuroSCORE: European System for Cardiac Operative Risk Evaluation

Table 2 – Respiratory and peripheral muscle strength, pulmonary function and functionality behavior of patients undergoing coronary artery bypass grafting

Variable	Preoperative	7th POD	p ^a	Δ
MIP (cmH ₂ O)	111 ± 10	78 ± 11	<0.01	33 ± 10
MEP (cmH ₂ O)	105 ± 13	70 ± 12	<0.01	35 ± 12
PEF (L/min)	381 ± 20	344 ± 22	0.23	37 ± 21
FIM	125 ± 2	118 ± 3	<0.01	7 ± 2
MRC	59 ± 1	56 ± 2	0.54	3 ± 2

a. Paired Student's t-test; POD – postoperative day; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; PEF: peak expiratory flow; FIM: functional independence measure; MRC: Medical Research Council

Table 3 – Correlation between pulmonary function variables and surgical risk scales of patients undergoing coronary artery bypass grafting

Variable	EuroSCORE		InsCor	
	r*	P	r*	P
Δ MIP	- 0.78	0.02	- 0.77	0.07
Δ MEP	- 0.22	0.53	- 0.73	0.01
Δ PEF	- 0.45	0.24	- 0.04	0.92
Δ FIM	- 0.79	0.01	- 0.89	0.02
Δ MRC	- 0.12	0.55	- 0.34	0.48

* Pearson Test; EuroSCORE: European System for Cardiac Operative Risk Evaluation; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; PEF: peak expiratory flow; FIM: functional independence measure; MRC: Medical Research Council

Discussion

In the present study, we found that the EuroSCORE had a strong negative correlation with MIP and FIM, while InsCor had a significant negative correlation with MIP, MEP and FIM.

There was a reduction in all variables related to pulmonary function when compared to the preoperative period. MIP had a 30% decline on the seventh postoperative day, corroborating with Schnaider et al.,¹⁶ who also showed a reduction in MIP. We obtained a reduction in MEP value of 33% and in PEF of 10% when compared with preoperative values.

On the other hand, Annoni et al.¹⁷ observed a significant increase in MEP and PEF, which may have been correlated with the small sample size, and collaboration and learning of patients to perform the tests, since they were evaluated daily from the first postoperative period until the day of discharge.

This study also corroborated the research conducted by Cordeiro et al.,¹⁰ proving the existence of a positive relationship between a cardiac risk scale and functionality in patients undergoing cardiac surgery. Patients at higher pre-surgery risk experienced worsening of functionality.

It is possible to identify a reduction in muscle strength in patients after surgery, which may be related to several factors related to the surgery itself. Guedes et al.¹⁸ described that thoracic surgical incisions generate a reduction in respiratory muscle strength, as they affect muscle integrity, directly changing its postoperative function and increasing the length of hospital stay.

Changes may occur due to dysfunction of the respiratory muscles and nerves resulting from the incision or due to changes in respiratory mechanics,¹⁹ confirming the findings of our study.

Cordeiro et al.³ reported that cardiac surgeries can cause systemic changes, given the complexity of the procedure: degree of sedation, CPB time, preoperative pulmonary and cardiac functions, which may influence the degree of functionality of these patients, besides mobility restriction due to ICU admission. As expected, there was a decline in functionality, as studies indicate the relationship of preoperative risk with worsening of functionality.^{4,10}

Fonseca et al.²⁰ pointed out that during the postoperative period, there is a need for pain and anxiety control. The authors mentioned that, in a study conducted by nurses in a hospital specializing in cardiology, it was identified that these factors motivate the administration of sedative and analgesic drugs, with consequent depression of the level of consciousness, increasing hospitalization time. These findings coincide with our results, leading to the hypothesis that the longer a person takes sedative drugs, the later will the functional independence be recovered.

In addition to these findings, Pardeans et al.²¹ reported that myocardial revascularization surgery and high surgical risk are associated with reduced exercise capacity for the surgical procedure. This may be related to the worsening of ventilatory muscle strength and pulmonary function, as observed in our study.

Another explanation for the decline in the variables presented in this study is sarcopenia.²² Many of our sample were elderly, which alone contributes to reduction of muscle mass and worsening of cardiac systolic function.

The development of tools that can predict outcomes is of fundamental importance to this population. Ivanov et al.²³ evaluated the use of preoperative pulmonary function testing to stratify the risk of patients undergoing cardiothoracic surgery and did not recommend its routine use due to its low sensitivity. This result reinforces the findings of our study, suggesting the need for a new assessment instrument.

Limitations of our study include the small sample size, lack of sample calculation, and insufficient data such as surgery time, medication use and pain scale, that could improve the interpretation of our results.

Conclusion

It was concluded that EuroSCORE had a strong negative correlation with MIP and FIM, while InsCor had a negative correlation with MIP, MEP and FIM. Given these results, it is evident that the both scales provided knowledge of the risks during surgery and detected the decline in the level of independence and pulmonary function of patients undergoing coronary artery bypass grafting. Further studies should be conducted, stratifying patients at higher risk of such decline, to implement specific interventions.

References

- Santos VM, Neto EN, Prado M, Nazario S, Shimoya-Bittencourt W, Salicio M.A, et al. Capacidade Funcional e Força Muscular de Pacientes Submetidos à Revascularização do Miocárdio. *J Health Sci.* 2018; 20(1): 45-9.
- Laizo A, Delgado FEF, Rocha GM. Complicações que aumentam o tempo de permanência na unidade de terapia intensiva na cirurgia cardíaca. *Rev. Bras. Cir. Cardiovasc.* 2010; 25(2):166-71.
- Cordeiro AL, Ávila A, Amorim N, Naisa I, Carvalho S, Guimaraes A, et al. Análise do grau de independência funcional pré e na alta da UTI em pacientes submetidos à cirurgia cardíaca. *Rev Pesq Fisioter.* 2015; 5(1):21-7.
- Mejia OAV, Lisboa LA, Puig LB, Moreira LFP, Dallan LA, Pomerantzeff P, et al. InsCor: um método simples e acurado para avaliação do risco em cirurgia cardíaca. *Arq Bras Cardiol.* 2013;100(3):246-54.
- Andrade ING, Oliveira JPSP, Moraes Neto FR, Silva ITC Andrade TG, Moraes CRR. Avaliação do EuroScore como preditor de mortalidade em cirurgia cardíaca valvar no Instituto do Coração de Pernambuco. *Rev Bras Cir Cardiovasc.* 2010;25(1):11-8.
- Mejia OAV, Matrangolo BLR, Titinger DP, Faria LBD, Dallan LRP, Galas FB, et al. Age, creatinine and ejection fraction score in Brazil: comparison with InsCor and the EuroScore. *Arq Bras Cardiol.* 2015;105(5):450-6.
- Carvalho MRM, Silva NASS, Klein CH, Oliveira GMMO. Aplicação do EuroSCORE na cirurgia de revascularização miocárdica em hospitais públicos do Rio de Janeiro. *Rev Bras Cir Cardiovasc.* 2010;25(2):209-17.
- Maturana MJ, Antunes AL, Bento BTS, Ribas PRS, Aquim EE. Escalas de avaliação funcional em unidade de terapia intensiva (uti): revisão sistemática. *Rev Inspir Mov Saúde.* 2017; abr/mai/jun;2017, 13(2) ed 42..
- Cavenaghi S, Ferreira LL, Marino LHC, Lamari NM. Fisioterapia respiratória no pré e pós-operatório de cirurgia de revascularização do miocárdio. *Rev Bras Cir Cardiovasc.* 2011; 26(3):455-61.
- Cordeiro AL, Brito A, Carvalho I, Oliveira J, Guimarães A, Araujo TM, et al. Risco Cirúrgico e Funcionalidade em pacientes submetidos à cirurgia cardíaca. *Int J Cardiovasc Sci.* 2016;29(5):385-9.

Author contributions

Conception and design of the research: Cordeiro ALL, Brito A, Almeida G, Jesus L, Oliveira F, Silva J. Acquisition of data: Brito A, Almeida G, Jesus L, Oliveira F, Silva J. Analysis and interpretation of the data: Cordeiro ALL. Statistical analysis: Cordeiro ALL. Writing of the manuscript: Cordeiro ALL, Brito A, Almeida G, Jesus L, Oliveira F, Silva J. Critical revision of the manuscript for intellectual content: Guimarães A, Barros R.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the *Faculdade Nobre* under the protocol number 2.490.540/2018. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

11. Ferreira LL. Escalas de avaliação funcional em terapia intensiva: revisão de literatura. *Rev Aten Saúde*. 2018;16(56):108-14.
12. Nunes MFS. Relação entre força muscular e função motora em pacientes com distrofia muscular de Duchenne: acompanhamento de quatro anos [Tese] São Paulo: Faculdade de Medicina .Universidade de São Paulo – USP; 2016.
13. American Thoracic Society, European Respiratory Society. Statement on Respiratory Muscle Testing. *Am J Respir Crit Care Med*. 2002;166:518-624.
14. Caixeta FM, Contato C. Avaliação do pico de fluxo expiratório máximo e da capacidade inspiratória em trabalhadores expostos a agentes agressivos ao sistema respiratório; *Rev. Mineira Ciênc Saúde*. UNIPAM. 2011;3:43-51.
15. Pena FM, Peixoto RS, Soares JD, Júnior HRP, Pena GDSA, Rosa Netto MV, et al. Aplicação do EuroScore em pacientes submetidos à troca valvar. *SOCERJ*. 2009; 22(3): 170-5.
16. Schnaider J, Karsten M, Carvalho T, Lima CW. Influência da força muscular respiratória pré-operatória na evolução clínica após cirurgia de revascularização do miocárdio. *Fisioter Pesq*. 2010;17(1):52-7.
17. Annoni R, Silva WR, Mariano MS. Análise de parâmetros funcionais pulmonares e da qualidade de vida na revascularização do miocárdio. *Fisioter Mov*. 2017; 26(3): 525-36.
18. Guedes GP, Barbosa YRA, Holanda G. Correlação entre força muscular respiratória e tempo de internação pós-operatório. *Fisioter Mov*. 2009; out/dez; 22(4):605-14.
19. Cavayas YA, Eljaiek R, Rodrigue É, Lamarche Y, Girard M, Wang HT et al. Preoperative Diaphragm Function Is Associated With Postoperative Pulmonary Complications After Cardiac Surgery. *Crit Care Med*. 2019;47(12):e966-e974.
20. Fonseca L, Vieira FN, Azzolin KO. Factors associated to the length of time on mechanical ventilation in the postoperative period of cardiac surgery. *Rev Gaúcha Enf*. 2014; 35(2): 67-72.
21. Pardaens S, Moerman V, Willems AM, Calders P, Bartunek J, Vanderheyden M et al. Impact of the preoperative risk and the type of surgery on exercise capacity and training after valvular surgery. *Am J Cardiol*. 2014 Apr 15;113(8):1383-9.
22. da Fonseca GWP, von Haehling S. Sarcopaenia complicating heart failure. *Eur Heart J Suppl*. 2019; 21(Suppl L):L20-L23.
23. Ivanov A, Yossef J, Tailon J, Worku BM, Gulkarov I, Tortolani AJ, et al. Do pulmonary function tests improve risk stratification before cardiothoracic surgery? *J Thorac Cardiovasc Surg*. 2016;151(4):1183-9.e3.

