

ORIGINAL ARTICLE

Intraoperative blood red cell saving effect on the homologous blood transfusion in adult patients undergoing heart surgery with cardiopulmonary bypass

Yazmin Rivera-San Martin, RN*, Roberto Solís-Carmona, RN**, María Alejandra Parra-Argudo, RN***, Guadalupe Arrieta-Arellano, RN*, and Julio César Cadena-Estrada, MSN****

*Perfusion Service; Instituto Nacional de Cardiología "Ignacio Chávez". Ciudad de México, MÉXICO.

**Perfusion Service; Hospital Central Sur de Alta Especialidad, PEMEX. Ciudad de México, MÉXICO

***Perfusion Service; Hospital Regional José Carrasco Arteaga (IESS) Cuenca, ECUADOR.

****Nursing Investigation Department; Instituto Nacional de Cardiología "Ignacio Chávez". Ciudad de México, MÉXICO.

Introduction. Erythrocyte cell saving is the best choice for the autologous preservation of red blood cells minimizing the damaging effects caused by cardiac surgery. **Objective.** To analyze the effect of intraoperative erythrocyte cell saving on the homologous transfusion of erythrocyte concentrate in adult patients undergoing cardiac surgery with cardiopulmonary bypass (CPB). **Methods.** A quantitative study with a descriptive and cross-sectional design was performed from January 2015 to December 2017 in patients undergoing cardiac surgery with CPB and cell savers. Analysis of the data was done with the SPSS program, version 19. **Results.** 75% of the total population were men, average age of the studied patients was 59.89 ± 9.39 years (40-81), prior to surgery 62% of patients were treated with anticoagulants. According to the Izaguirre scale 85.2% had a risk of habitual bleeding and the remaining 14.8% had a high risk of bleeding. **Conclusions.** Patients undergoing a cell saving procedure had a lower risk of exposure to homologous transfusion, mainly to erythrocyte concentrate. This does not completely exclude the risk associated with the use of homologous blood, but decreases it.

Key words: Autologous blood transfusion; Blood preservation; Cardiopulmonary bypass; Cardiac surgery.

Introducción. El rescate celular de eritrocitos es la mejor elección para la conservación de hemáties de manera autóloga y con ello minimiza los efectos deletéreos causados por la cirugía cardíaca. **Objetivo.** Analizar el efecto que tiene el rescate celular de eritrocitos intraoperatorio sobre la transfusión homóloga de concentrado eritrocitario en pacientes adultos sometidos a cirugía cardíaca con CEC. **Métodos.** Se realizó un estudio cuantitativo con un diseño descriptivo y transversal de enero de 2015 a diciembre de 2017 de los pacientes sometidos a cirugía cardíaca con CEC y rescatador celular. El análisis de los datos se realizó con el programa SPSS versión 19. **Resultados.** El total de la población estudiada el 75% eran hombres, la edad promedio de los pacientes de estudio fue de 59.89 ± 9.39 años (40-81), previo a la cirugía el 62% de los pacientes eran tratados con anticoagulantes. Considerando diversos factores se observó de acuerdo a la escala de Izaguirre que el 85.2% tenían un riesgo de sangrado habitual y el 14.8% restante un alto riesgo de sangrado. **Conclusiones.** Los pacientes sometidos al procedimiento de rescate celular presentan menor riesgo de exposición a transfusión homóloga principalmente a concentrado eritrocitario, esto no excluye en su totalidad el riesgo que conlleva la utilización de sangre homóloga pero si la disminuye.

Palabras clave: Cirugía cardíaca; Circulación extracorpórea; Conservación de la sangre; transfusión de sangre autóloga.

Cir Card Mex 2020; 5(4): 116-121.

© 2020 by the Sociedad Mexicana de Cirugía Cardíaca, A.C.



Homologous blood transfusions during heart surgery is a frequent indicated procedure to replace blood losses that put patient live at risk or to improve in a precise

and fast manner their condition. During this process there is some risk for adverse reactions, and get some infectious contagious diseases, such as HIV virus, hepatitis B and C [1].

Homologous blood transfusion represents a financial burden for the patient as well as for the institution. During the 70's, the WHO (World Health Organization) made a review where it is mentioned that selling blood is an income source

Corresponding author: Lic. Yazmin Rivera San Martin
email: yazrivsa@gmail.com

for low income people like drug and alcohol addicts. In developing countries one blood unit was sold for 2 to 4 US dollars. Nowadays, we might conclude that these illegal practices still continue placing the patients at high risk of contracting infectious contagious diseases, and increasing the expenses [2]. On the other hand, the patients could have secondary complications to homologous blood transfusion increasing hospital stay, morbimortality and delayed recovery. Another limiting factor to be considered is the one related to religion. It is well known that Jehovah's Witnesses do not allow blood transfusions.

Currently, due to technological advances, procedures have been developed that reduce the number of homologous transfusions like the cell saving procedure characterized to be an extracorporeal procedure inside the operating room where autologous blood losses during surgery are processed allowing that only the red blood cells return to the patient's bloodstream.

Studies in Spain [3] Costa Rica [4] and México [5] have described that cell savers reduce the amount of administrated erythrocyte concentrates, the number of donors and the risk of nosocomial infections in 60%. Blood savers diminish the request of homologous blood transfusion favoring an early recovery of the patients in comparison with those not underwent the same procedure.

Despite the published evidence at our institution, it has been observed that the patients who had cardiac surgery with a low bleeding risk, very few units of blood components were administrated. In cases where patients were reoperated with a high bleeding risk, 15 to 20 blood units were used, pushing them at high risk.

Therefore, the aim of this research study was to analyze and determine the effect of the transoperative erythrocyte saving procedure on the homologous blood transfusion in adult patients undergoing cardiac surgery with cardiopulmonary bypass.

This study is justified due to very few researches done in Mexico making evident the benefits of the intraoperative cell saving procedure after surgery like less bleeding within the first 24 hours after the operation, early recovery and extubation, optimized cost-effectiveness, minimized hospital stay and in the case of Jehovah's Witnesses the possibility of an autologous transfusion.

MATERIAL

A quantitative study with a descriptive and transversal design was performed from January 2015 to December 2017 in patients who had heart surgery with cardiopulmonary bypass (CPB) and cell savers. For this study the variable cell saver has been defined as that procedure where electronic devices are used mainly for intra or postoperative autotransfusion of red blood cells in certain surgeries where a significant bleeding is foreseen (>20% of basal blood volume).

The non-probabilistic sample n=108 patients was conveniently selected. It included male and female adults over the age of 40 submitted to heart surgery for the first time with cardiopulmonary bypass (CPB) the ones with incomplete data were discarded as well as those who had incidental intraoperative complications, coagulopathies or died during surgery.

To recollect the data an expert validated instrument with three sections was selected. The first one included 12 items for sociodemographic variables (date, registry, socioeconomic classification, name, gender, bed number, number of operating room, time when surgery started, presurgical medical diagnosis, bleeding risk scale (Izaguirre), mortality scale (EuroSCORE II) and scheduled surgery; the second one with 9 items for preoperative biochemical parameters like hemoglobin, hematocrit, platelets, activated coagulation time (ACT) prothrombin time (PT), partial thromboplastin time (PTT), international adjusted index (INR), aortic cross-clamp time (CCT), and cardiopulmonary bypass time (CPBT); and in the last one items to follow-up the patient after surgery with the same parameters where amount of transfused blood components and amount of bleeding within 24 hours after surgery were included.

Recollection of data was done by means of a first visit to obtain basal variables and the signed consent of each patient, during the transoperative period a cell saver was used to rescue erythrocytes as well as a record of transoperative data and finally a follow-up within the first 24 hours after surgery in the ICU was done.

Analysis of data was performed with the Statistical Package for the Social Sciences Program (SPSS) version 19 through measures of central trend and dispersion for quantitative variables: hemoglobin, hematocrit, platelets, PT, PTT, INR, bleeding, aortic CCT, CPBT; frequencies and percentages of qualitative variables: type of surgery, antiplatelet drugs, anticoagulants, and comorbidities, as well as an inferential analysis through Pearson's correlation coefficient testing considering a statistical significance of $p < 0.05$.

According to the NOM-012-SSA3-2012 that establishes the criteria for the execution of health research projects [6] and to the Regulation of the General Health Law [7] concerning health investigation, this study was considered low risk because data were obtained through common procedures. In the same way researchers followed the Nuremberg Code and the Helsinki Declaration [8] asking for the informed consent and the registry before the Nursing Research Committee (DIE/TT/16/2015)

RESULTS

According to demographic data of the studied sample (n=108) 75% were men with a prevalent medical diagnosis of coronary heart disease and heart valve disease; therefore, 75% underwent coronary bypass surgery and mitral valve replacement. Average age of the studied patients was 59.89 ± 9.39 years (40-81), patient's ages ≥ 52 were found above quartile 25.

Table 1. Central trend measure and dispersion of quantitative variables in adult patients who underwent erythrocyte cell saving during heart surgery with cardiopulmonary bypass.

| | Preoperative (n= 108) | | | | | Postoperative (n= 108) | | | | |
|-----|-----------------------|--------|--------|-----------------|-----------------|------------------------|--------|--------|-----------------|-----------------|
| | Rank | Media | SD | Q ₂₅ | Q ₇₅ | Rank | Media | SD | Q ₂₅ | Q ₇₅ |
| HB | 9.0-19 | 14.461 | 1.809 | 13.4 | 15.5 | 9.1-16 | 10.689 | 1.5805 | 9.5 | 11.775 |
| HT | 27.2-57 | 43.371 | 5.375 | 40.625 | 46.7 | 29.5-49.5 | 32.362 | 5.1902 | 28.525 | 35 |
| PL | 96.0-461 | 226.13 | 66.434 | 183.25 | 261.75 | 365-402 | 173.5 | 62.982 | 128.5 | 203 |
| PT | 10.0-25 | 12.189 | 1.964 | 11 | 12.4 | 16-26 | 12.814 | 1.7913 | 12 | 13.2 |
| PTT | 22.9-58 | 33.026 | 6.332 | 29 | 35.975 | 24.0-55.4 | 31.136 | 7.0397 | 28 | 32 |
| INR | 0.7-2.3 | 1.092 | 2.122 | 1 | 1.133 | 0.9-1.8 | 1.144 | 0.1344 | 1 | 1.2 |

HB: hemoglobin, HT: hematocrit, PL: platelets, PT: prothrombin time, PTT: thromboplastin time, INR: International Normalized Range

Prior to surgery, 62% of the patients were treated with anticoagulants like acenocoumarin, non-fractionated heparin or low molecular weight heparin and 70.4% with antiplatelet drugs like aspirin and clopidogrel. Considering several factors, it was observed that according to Izaguirre's scale 85.2% had a habitual bleeding risk and the remaining 14.8% a high bleeding risk. According to the EuroSCORE II scale below percentile 71.3 patients with low mortality risk were found and above percentile 86.1 were the patients with high mortality risk.

Hematological data before the surgery were as follows: Hb 14.46 ± 1.80 g/dl (min 9 – max 19), Ht 43.37 ± 5.37 % (27.2-57), platelets 226.13 ± 66.43 ml (96-461); PT 12.18 ± 1.96

sec (10-25), PTT 33.02 ± 6.33 sec (22.9-58), INR $1.09 \pm .1.09$ (0.7-2.3) considering them as normal parameters. Each one of them diminished after the surgical procedure, but within normal parameters (Table 1).

In 100% of the studied population the circulating blood volume 4868.54 ± 942.01 ml (2883-7700) equivalent to a 2097.66 ± 586.54 ml (961-4158) of red blood cells was calculated. Once in surgery, CPB time was of 115.82 ± 32.82 minutes (34-186), with an aortic CCT of 74.58 ± 22.49 minutes (23-137), initial ACT of 125.29 ± 16.005 seconds (88 to 165) and final ACT of 129.28 ± 15.52 seconds (86-165). All the patients underwent a cell saving procedure where a final erythrocyte volume of 866.33 ± 394.68 ml (0-2134) was obtained

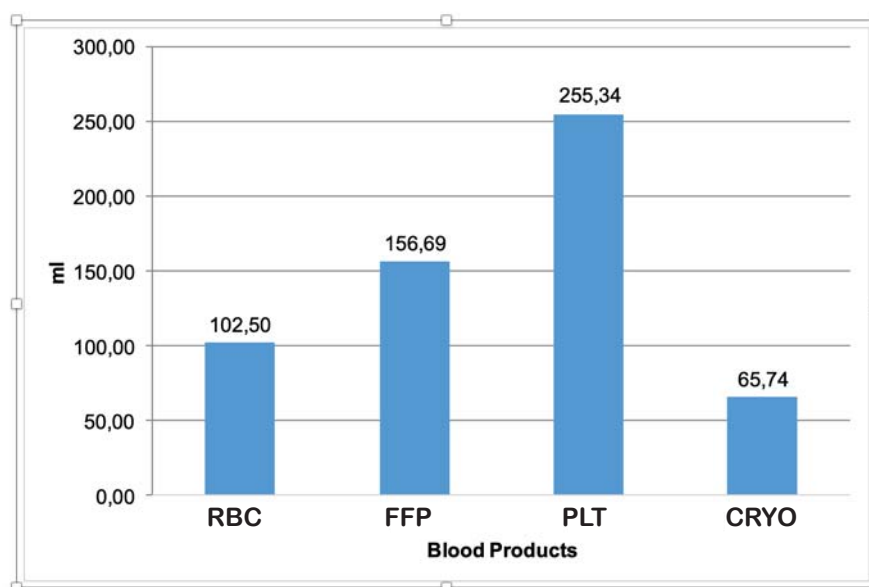


Figure 1. Postoperative transfused homologous blood components.

RBC: Red blood cells, FFP: Fresh frozen plasma, PLT: Platelets, CRYO: Cryoprecipitates

Table 2. Central trend measure and dispersion of quantitative variables in adult patients who underwent erythrocyte cell saving during heart surgery with cardiopulmonary bypass.

| | Transoperative (n= 108) | | | | |
|---------------------------------|-------------------------|---------|---------|-----------------|-----------------|
| | Range | Median | SD | Q ₂₅ | Q ₇₅ |
| Aortic cross-clamp time | 23-137 | 74.58 | 22.49 | 59.25 | 89.5 |
| Cardiopulmonary bypass time | 34-186 | 115.82 | 32.827 | 92.5 | 139.45 |
| Basal activated clotting time | 88-165 | 125.29 | 16.005 | 114 | 136 |
| Final activated clotting time | 85-165 | 125.29 | 15.529 | 118.25 | 140.75 |
| Circulating blood volume | 2883-7700 | 4868.54 | 942.011 | 4301.25 | 5386 |
| Packed red blood cells | 961-4158 | 2097.66 | 586.541 | 1667.25 | 2363.5 |
| Recovered and transfused volume | 0-2134 | 866.33 | 394.682 | 612.5 | 1129.75 |
| Final bleeding | 100-2350 | 594.33 | 352.276 | 335 | 665 |
| 24 hours bleeding | 40-1500 | 310.91 | 239.641 | 160 | 380 |
| Protamine | 0-567 | 356.35 | 97.49 | 281.5 | 450 |
| Antifibrinolytics | 0-35 | 6.81 | 8.523 | 0 | 10 |

and transfused after CPB and before leaving the operating room. Total bleeding after surgery was of 549.33 ± 352.27 ml (100-2350) and to reverse heparin anticoagulant molecular union, protamine of 35 ± 97.49 mg (180-567) was administered. To decrease the fibrinolytic effect aminocaproic acid 6.81 ± 8.52 mg (0-35) was administered (Table 2).

Bleeding within the first hours after surgery during ICU stay was of 310.91 ± 230.64 ml (40-1500 ml), which is correlated with CBPT ($r=0.309$, $p=0.001$), and the time of aortic clamping ($r= 0.245$, $p=0.011$), in the case of the amount of transfused platelets it is related to CPBT ($r=0.315$, $p=0.001$). However, after 24 hours the transfusion of globular pack, fresh plasma, platelets and cryoprecipitates is not related to de CBP time.

It is to highlight that with the use of cell savers the transfusion of homologous blood concentrates within the 24 hours after surgery dropped to 102.51 ml \pm 199.22 (0-938) As the blood saver only rescued red blood cells during surgery, it was necessary to administer fresh frozen plasma 156.69 ± 207.87 ml (0-717), platelets 255.34 ± 188.17 ml (0-702) and cryoprecipitates 65.74 ± 85.07 ml (0-423) during the ICU stay (Fig. 1).

Finally, extubation time is bilaterally correlated with CPBT ($r=0.255$, $p=0.008$) and aortic CCT ($r=0.253$, $p=0.008$) that shows that a longer exposure to CBP delays extubation time.

DISCUSSION

Our study showed that a cell saving procedure is a strategy to keep blood and recover erythrocytes in a patient undergoing heart surgery with CPB, data that agree with a study of Costa Rica [9] as well as confirmed by Rubens [10] and Murphy [11], where intubation time and the risk of death

fell down. It is also worth mentioning that recovery time of the patients in the ICU was shorter related to early extubation (within the first 12 hours) and acceptable hemodynamic profile reflected in the first 24 hours course. Therefore, this technique should be used in patients undergoing cardiac surgery with CPB and high mortality risk.

The cell saver used during operation obtains erythrocyte concentrate directly from operative field in an effective way. This has shown a significant reduction in homologous blood transfusion. However, studies performed by Careaga [4] and Laub [12] have described this technique does not achieve to recover optimal amounts of plasma, platelets and coagulation factors. Therefore, if the patient is exposed to longer surgery times, these losses increase the consumption of plasma and homologous platelets. These data are clearly reflected in this research and indicate to choose another blood conservation strategy that potentiates the benefits in the recovery of plasma and platelets.

This study showed a positive effect of the cell saver in adult patients who underwent heart surgery with CPB regardless gender and type of surgery by decreasing homologous blood requirements, and achieving an early extubation (within the first 12 hours after operation) and hemodynamic stability in the first 24 hours. These our data are in accordance with prior published studies; however, the increased number of platelet and plasma transfusions leads us to think in another strategy to preserve blood components such as poor platelet plasma (PPP) and rich platelet plasma (RPP), to eventually avoid any homologous plasma and platelet transfusion.

Considering the costs per unit of platelet apheresis (MXN \$7,165), platelet concentrate (MXN \$946), frozen fresh plasma (MXN \$1000), and erythrocyte concentrate (MXN \$1500) according to data provided in 2015 by the Social Service Department of our institution, we can infer that the cost of

processing blood components is too high for the institution and patients, not to mention if added laboratory costs for viral panels on potential donors. Thus, these transfusions are even more expensive. Therefore, we intend to perform a second study where cell savers are combined with plasmapheresis to diminish the requirements of homologous plasma and platelets using the same cell saver equipment and adding bags to recollect rich platelet plasma. With the option of preoperative abduction of the cell saver equipment, it is possible to separate plasma and platelets from previously recollected whole blood in bags for normovolemic hemodilution (NVH). Normally, the separation of total blood is done for the patient receiving autologous plasma supply that contains coagulation factors and platelets at the end of the procedure as reported in the evidence. With this equipment it is possible to recollect PPP and RPP in separate or joint bags [13].

Within blood conservation strategies to control intraoperative blood losses, hemostatic pharmacological agents provide an additional benefit in situations of excessive surgical bleeding, hyperfibrinolysis, in patients with hemostatic defects or in those who reject blood transfusion as previously referred [14-18], and the result of this study herein by us.

In daily practice, the professional perfusionist should be highly skilled in the management of these drugs anticipating possible complications related to excessive bleeding. Prophylactic use is justified in special situations according to the context of each patient. Desmopressin, tranexamic acid, epsilon aminocaproic acid, recombinant factor VII and prothrombin complex concentrate are included in this sort of drugs. These drugs considerably drop down the fibrinolysis, while protect the platelet membrane, reduce postoperative bleeding, total blood loss and amount of transfusions during cardiac surgery. (Evidence level A, class I recommendation) [19-20].

The transfusion of blood components is related to an increased risk of the transmission of infectious contagious diseases, higher morbimortality, surgery costs and longer hospital stay [21]. Through the cell saver, the perfusionist seeks to reduce the use of homologous blood as has been done in this study. Nevertheless, they must keep an eye on any bleeding during the perioperative and immediate postoperative period in individuals undergoing cardiac surgery with CPB. They must identify patients with bleeding, perform strategies of blood conserving and prophylactic measures in patients who are Jehovah's witnesses or with a less common Rh factor.

The use of blood conserving strategies is very important in patients who undergo heart surgery with CPB because they avoid homologous blood minimizing its deleterious effects like infectious contagious diseases and an increased systemic inflammatory response as observed in patients of this study where less than 110 ml of erythrocyte concentrate in average was transfused needing less mechanic ventilation. Also, there was an absence of a vascular reactivity secondary to a systemic inflammatory response but it is necessary to add a technique of plasmapheresis due to an increased platelet and plasma consumption which are discarded by the cell saver.

In addition to this fact, from January 2015 to December 2017, 334 erythrocyte concentrates for 108 patients have been recovered where the cost of homologous blood would have generated a cost of MXN \$567,800 pesos, but by using a cell saver this generated an expense of MXN \$1,134,598 pesos, which is more expensive than a homologous pack but on a long term, the cost-benefit for the patient and institution is favorable as described by Almeida [22]. Therefore, it is inferred that the benefit will be greater when adding plasmapheresis because the cost of blood components could be significantly reduced.

It is concluded that patients who undergo a cell saving procedure have less homologous transfusions, mainly erythrocyte concentrates. This does not completely exclude the risk that carries its use but diminishes it.

The cell saver of erythrocytes as a strategy of blood conservation can and must be used in all patients who undergo heart surgery with or without CPB with a high risk for bleeding, since more benefits have been shown in adult patients with CPB. However, it is important to combine different blood conserving strategies, such as intraoperative plasmapheresis with the purpose of diminishing the risk of autoimmune response and infectious diseases. Also, autologous transfusion not only of erythrocytes but also for optimal requirements of autologous plasma and platelets.

Results should be considered with caution because there were some limitations of this study. More controlled prospective research is required that not only shows the benefits of the cell saver but also of intraoperative plasmapheresis considering cost impact, hospital stay and the patients evolution. In Mexico there is not enough research that supports the consulted literature about this type of surgery.

ACKNOWLEDGEMENT

We thank the Nursing Investigation Department for all the support and the provided facilities for this study.

FUNDING: None

DISCLOSURE: The authors have no conflicts of interest to disclose.

REFERENCES

1. Anestesia Cardiovascular (Spanish Edition) de Ortiz Luna, P. 4a edition. Published by Alfil, México (2013).
2. Organización Mundial de la Salud, Nota Descriptiva. Disponibilidad y seguridad de la sangre a nivel mundial. Ginebra. OMS, 2017. <http://bit.ly/1kIvbe5>.
3. Salazar-Ramírez C, Daga-Ruiz D, Cota-Delgado F, Fernández-Aguirre C, Fernández-Añon JM, García-Fernández JM. (2010). Utilidad de la plasmaféresis en cuidados intensivos. *Med Intensiva* 2010;34:74-8.
4. Induni-López E, Alvarado M, Méndez E, Pucci J. (2003). Autotransfusión y terapia de componentes sanguíneos autólogos en cirugía cardíaca: consideraciones generales y experiencia en el Hospital México. *Rev Costarric Cardiol* 2003;5:9-18.
5. Careaga-Reyna G, Ramírez-Castañeda A, Sánchez-Ramírez O, Jiménez-Valdivia M, Arellano-Villavicencio Á, Argüero-Sánchez R. Sistema recuperador celular en cirugía cardíaca con derivación cardiopulmonar para disminuir el uso de sangre homóloga. *Cir Ciruj* 2001;69:291-4.
6. Secretaría de Salud. Reglamento de la ley general de salud en materia de investigación. México. Diario Oficial de la Federación. 2014. <http://bit.ly/1SBpqPT>
7. Tribunal Internacional de Núremberg, 1947. Ética Médica, Código de Nuremberg, Experimentos médicos permitidos. La Plata Argentina. 1989.
8. La Asociación Médica Mundial (AMM). DECLARACION DE HELSINKI DE LA ASOCIACION MEDICA MUNDIAL. In Principios éticos para las investigaciones médicas en seres humanos; Octubre 2008; Helsinki.
9. Cordero R, Vives N, Villalobos F, Vieto P, Cartín J. Plasmaféresis en Costa Rica. *Revista Médica de Costa Rica* 1972;39: 65-75.
10. Rubens FD, Fergusson D, Wells PS, et al. Platelet-rich plasmapheresis in cardiac surgery: a meta-analysis of the effect on transfusion requirements. *J Thorac Cardiovasc Surg* 1998;116:641-7.
11. Murphy GJ, Rogers CS, Lansdown WB, et al. Safety, efficacy, and cost of intraoperative cell salvage and autotransfusion after off-pump coronary artery bypass surgery: a randomized trial. *J Thorac Cardiovasc Surg* 2005;130: 20-8.
12. Laub GW, Dharan M, Riebman JB, et al. The impact of intraoperative autotransfusion on cardiac surgery. A prospective randomized double-blind study. *Chest* 1993;104:686-9.
13. Sorin Group. Sorin Xtra. Manual del Usuario. Sorin Group. 2011. https://www.google.com.mx/search?q=sorin+Group.+Sorin+Xtra.+Manual+del+Usuario.+Sorin+Group.+2011&spell=1&sa=X&ved=2ahUKEwj-hpye6N_qAhVLAp-0JHZiEA5MQBSgAegQICxAs&biw=1398&bih=819. Accessed July 21, 2020.
14. Rosales-Gutiérrez AO, Galván-Talamantes Y, Espinoza de los Monteros-Estrada I. Técnicas farmacológicas de ahorro hemático. *Rev Mex Anest* 2015;38:56-64.
15. Arrieta-Arellano G. Intervenciones para conservar la sangre en cirugía cardíaca con circulación extracorpórea. *Rev Mex Enferm Cardiol* 2012;20:17-20.
16. Koch CG, Li L, Duncan AI, et al. Morbidity and mortality risk associated with red blood cell and blood-component transfusion in isolated coronary artery bypass grafting. *Crit Care Med* 2006;34:1608-16.
17. Arrieta AG, Ramírez VYE, Martínez JM. Efecto de las estrategias de conservación sanguínea sobre la transfusión en pacientes con circulación extracorpórea. *Rev Mex Enf Cardiol* 2016;24:5-11.
18. Serrano-Valdés X. Hemotransfusión como factor de riesgo en cirugía cardíaca. *Arch Cardiol Méx* 2006;76:86-91.
19. Society of Thoracic Surgeons Blood Conservation Guideline Task Force, Ferraris VA, Brown JR, et al. 2011 update to the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists blood conservation clinical practice guidelines. *Ann Thorac Surg* 2011;91:944-82.
20. Souza HJ, Moitinho RF. Strategies to reduce the use of blood components in cardiovascular surgery. *Rev Bras Cir Cardiovasc* 2008;23:53-9.
21. Medina JR. Enfermedades infecciosas transmitidas por transfusión. Panorama internacional y en México. *Gac Méd Méx* 2014;150:78-83.
22. Almeida RM, Leitão L. The use of cell saver system in cardiac surgery with cardiopulmonary bypass. *Rev Bras Cir Cardiovasc* 2013;28:76-82.