Editorial

An investment for the future

Carlo Pace Napoleone

Pediatric Cardiac Surgery, Regina Margherita Children's Hospital, Torino, Italy

Correspondence to: Carlo Pace Napoleone, MD, PhD. Pediatric Cardiac Surgery, Regina Margherita Children's Hospital, Piazza Polonia 94 - 10126 Torino, Italy. Email: cpacenapoleone@cittadellasalute.to.it.

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The modern pediatric cardiac surgery is continuously improving its results and mortality is no more the biggest problem to face with. This is the result of the increased skill in treating our patients not only of the surgeons but of all the team in general, with the consequent reduction of mortality in the nightmare cases of yesterday and the near zero incidence of postoperative problems in the easier cases. One fundamental hand to get these results comes also from the technical improvements that biomedical research makes continuously available for operators. This is particularly evident in neonatal surgery and in palliative operations. These patients, together with the huge and constantly increasing amount of grown-up congenital heart (GUCH) patients, constitute a population at high risk of reoperations. Repeat sternotomy (RS) in congenital heart surgery has always been common for many reasons among which the presence of associated pathology, the staged procedures and the nature of palliation. Moreover, in recent years, for the reasons previously listed, the number of reintervention is constantly increasing. The analysis of 92,603 operations listed in the Society of Thoracic Surgeons Congenital Heart Surgery Database (STS-CHSD) conducted in the 5-year analytic window of January 1, 2007 to December 31, 2011 demonstrated that about 33% of them [30,673] were redo operations (1). From the analysis of the same database, this percentage was 30.73% in 2006 and 28.4 in 2002 (2).

This data confirms once more that reoperations represent an important portion of activity in pediatric cardiac surgery. Staged strategies and the necessity to deal with the natural patient growth and with a very long follow-up leave the opportunity of reintervention always open. Also an easy and durable atrial septal defect closure, analysed in more than 15,000 patients at 15 years follow-up, has a reintervention-free rate of 99%, approaching to but not reaching zero (3). At the end, we can consider all congenital patients potentially at risk of reoperation for problems related to first correction or to the cardiopathy or anyway for newly onset acquired cardiac problems. If we would like to stratify the risk of reintervention in congenital patients, we can consider that this will be sure in all palliative surgeries and in general in staged procedures, likely in cases like transannular repair of tetralogies of Fallot, in valve reparative surgery, in operations with artificial valves or conduits implant, and possible practically in all the remaining cases.

The necessity to reopen a chest brings an additional risk to the reoperation. This risk is difficult to quantify, and is reported in literature in a very wide range. It was estimated around 5% in the 90ties (4,5), with a trend toward reduction in the recent years. Kirshbom *et al.* reported that in one thousands RS mortality was not significantly different from primary sternotomy, and re-entry injury depends on sternotomy number (6). This result is confirmed by Morales *et al.* who stated that the risk of a major injury upon RS can be so low (0.3%) that it is not statistically different than for primary sternotomy (0%). Moreover, in their experience the morbidity and mortality from RS, even for patients who sustain an injury, is negligible (2). It is evident that in recent years mortality secondary to catastrophic events at chest reopening is low and doesn't add risk at operation itself. But it is

equally evident that reoperations have an impact on the resources that are necessary for these patients. Specifically, a statistically significant increased necessity of transfusions and a longer operating room, ventilation and ICU stay were necessary in 195 RS procedures compared to 250 primary sternotomy group, as reported by Yin *et al.* (7). An attempt to quantify the cost of RS was provided by Morales *et al.* who analyzed the results of 29 retrospective studies focused on RS in cardiac surgery (8). Sixty-six cases of catastrophic hemorrhage occurred among 3,640 (1.5%) patients from 15 studies providing sufficient data. The majority of catastrophic hemorrhage cases (55 of 66; 83.3%) required emergent placement on CPB; 10 (15.2%) cases received emergent blood or blood product transfusions. Applying cost estimates for hospital resources to published complication rates, it is possible to estimate that for every 100 cases undergoing cardiac reoperation, resource consumption in RS may increase the direct healthcare costs by over $2.4 million (8). At the end, with all the limitations due to the difficulty to record all the complications directly due to RS, it is evident that the cost of these operations is higher than a primary sternotomy, not only if a catastrophic event occur during operation but also for the increased time that the surgeons need to go on cardiopulmonary bypass (CPB), that means more Operating Room occupation but also longer anesthetic time, higher surgical trauma and so on.

The possibility to facilitate RS and to reduce the catastrophic adverse events in these patients should have a positive impact on the patient outcome and on the costs for healthcare system. Many preventive strategies have been proposed to prepare to chest re-entry and to reduce the risk of RS. The scrupulous use of these strategies demonstrated to be effective in the literature and from the evidence-based experience and must be considered a real investment for the future of these patients. Among these strategies, some try to reconstitute the physical barrier that is naturally present between the heart and the sternum. The simple pericardial closure that interposes a natural barrier between heart and sternum is not always possible, especially if an autologous pericardial patch has been used, and can result in adverse hemodynamic effect on left ventricular function—cardiac index (9). Artificial pericardial replacement has been proposed with many membranes among which the PTFE membrane (PRECLUDE® Pericardial Membrane, Gore, Flagstaff, Arizona, USA) seems to be the more effective. This is reported with good results at re-sternotomy (10) but with chronic inflammation and foreign body reaction leading to exaggerated response (11) and not always protecting for dislodgement (12). Some other strategies try to interfere with the mechanism of adhesions formation. This can be obtained with fibrinolytic drugs like recombinant tissue plasminogen activator or streptokinase (13), with an obvious impact on post-operative bleeding, or creating a temporary barrier between the epi- and pericardium in the first 3 post-operative weeks, the crucial period for adhesions formation (14). Many efforts have been devolved on this second option, essentially with hyaluronic acid or poly-ethylene-glycol membranes or solutions. The last have proved to be very effective in other surgeries with laparotomic approaches, but are rapidly dislodged from mediastinum by drains in sternotomies and its results are not always satisfying. Sodium hyaluronate-based membranes demonstrated to be effective in reducing post-operative adhesions associated with infant cardiac surgery and their use is recommended in pediatric cardiac surgery when staged surgical interventions are necessary (15).

The absorbable hydrogel spray reported by Hasaniya *et al.* (16) was proposed on the market about 10 years ago (Coseal Surgical Sealant, Baxter Healthcare, Deerfield, IL, USA). It is a hydrogel initially designed to act as a sealant around a sutured site. It is composed of two synthetic polyethylene glycols dilute in a hydrogen chloride solution and sodium phosphate/sodium carbonate solution. The material is a flexible, degradable hydrogel that adheres to tissue and prevents additional blood loss. Its anti-adhesive action is the results of its capacity to swell fixing water so to reach a volume up to four times greater than the initial one just after few hours after application. In this way it acts as a barrier between the epi- and the pericardium and consequently prevents the formation of adhesions. It does not act as a matrix for cellular infiltration and does not produce marked necrosis or inflammation or increased rates of infection. Coseal® is easily sprayed on the heart, gel within seconds of application and is completely reabsorbed by 30 days. The only concern is due to the application dose that must be strictly related to patient weight. Cardiac tamponade secondary to the volume increase in case of over dosage has been described in some patients (17). The reported experiences were positive from the beginning (17,18). It proved to be very effective in reducing pericardial adhesions so that re-sternotomy can be performed with a very low risk of heart damage. Moreover, the advantages of a sealant attribute can be useful in preventing and minimizing serous leakage from prostheses or bleeding in general. In the first reported multicentric study, 76 patients were treated

with Coseal® application during the first reoperation (19). Thirty-six of these patients underwent chest reopening at a mean interval of 8 months. Adhesions were classified according to site and grade, in a manner very similar to that described in Hasaniya *et al.* (16). In particular, around 85% of adhesions were allocated the least severe classification of filmy and avascular. In twenty patients (57%) only filmy and avascular adhesion were founded at reoperation. In this study, a control group was not provided, but the experience was surely interesting (19).

My centre was one of those who participated to this study and since then we are using Coseal® surgical sealant in all patients potentially at risk for RS, with a very low enrolment threshold. Care is given to the dose, especially in neonates, where the risk of cardiac tamponade is real. In some operation, the sealing effect of Coseal® can be useful in case of small entity bleeding or oozing. In case of anatomical reasons that can make RS particularly dangerous, like conduit implant, after Coseal administration the pericardium is closed with the aid of a PTFE membrane (PRECLUDE® Pericardial Membrane). In these patients the anti-adhesive effect of Coseal® counteract the foreign body reaction of the membrane, leading to a perfect mechanical barrier underneath the sternum and filmy adhesion in the pericardium. With this strategy in the last five years 233 RS were performed with 4 adverse events causing bleeding from right ventricle-pulmonary artery biological conduit [2], infundibular patch [1] and single atrium [1] laceration. All patients underwent emergency CPB via femoral vessels and the operation was conducted without subsequent problems. There was no mortality or morbidity related to RS.

The paper by Pace Napoleone *et al.* closed with these words: "Regarding study weaknesses, our investigation lacked controls, and it is hoped that a controlled study will shortly be designed and commenced" (19). It's very important that about ten years later this claim produced the paper by Hasaniya *et al.* that confirm the efficacy of Coseal® in preventing adhesion and reducing the risk of chest reopening (16). A more extensive use of this material is advisable to reduce the risk secondary to sternal reopening and to make reoperation much more easy to deal with.

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Footnote

Conflict of Interest: The author has no conflicts of interest to declare.

References

1. Jacobs JP, Mavroudis C, Quintessenza JA, et al. Reoperations for pediatric and congenital heart disease: an analysis of the Society of Thoracic Surgeons (STS) congenital heart surgery database. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu 2014;17:2-8.
2. Morales DL, Zafar F, Arrington KA, et al. Repeat sternotomy in congenital heart surgery: no longer a risk factor. Ann Thorac Surg 2008;86:897-902.
3. Lange R, Schreiber C, Günther T, et al. Results of biventricular repair of congenital cardiac malformations: definitive corrective surgery? Eur J Cardiothorac Surg 2001;20:1207-13.
4. DeLeon SY, LoCicero J 3rd, Ilbawi MN, et al. Repeat median sternotomy in pediatrics: experience in 164 consecutive cases. Ann Thorac Surg 1986;41:184-8.
5. Russell JL, LeBlanc JG, Sett SS, et al. Risks of repeat sternotomy in pediatric cardiac operations. Ann Thorac Surg 1998;66:1575-8.
6. Kirshbom PM, Myung RJ, Simsic JM, et al. One thousand repeat sternotomies for congenital cardiac surgery: risk factors for reentry injury. Ann Thorac Surg 2009;88:158-61.
7. Yin CH, Yan J, Li SJ, et al. Effect analysis of repeat sternotomy in pediatric cardiac operations. J Cardiothorac Surg 2015;10:179-83.
8. Morales D, Williams E, John R. Is resternotomy in cardiac surgery still a problem? Interact Cardiovasc Thorac Surg 2010;11:277-86.
9. Rao V, Komeda M, Weisel RD, et al. Should the pericardium be closed routinely after heart operations? Ann Thorac Surg 1999;67:484-8.
10. Jacobs JP, Iyer RS, Weston JS, et al. Expanded PTFE membrane to prevent cardiac injury during resternotomy for congenital heart disease. Ann Thorac Surg 1996;62:1778-82.
11. Ozeren M, Han U, Mavioglu I, et al. Consequences of PTFE membrane used for prevention of re-entry injuries in rheumatic valve disease. Cardiovasc Surg 2002;10:489-93.
12. Bogers AJ. Massive bleeding at resternotomy despite a polytetrafluoroethylene surgical membrane. J Thorac

Cardiovasc Surg 1995;110:274-5.
13. Wiseman DM, Kamp L, Linsky CB, et al. Fibrinolytic drugs prevent pericardial adhesions in the rabbit. J Surg Res 1992;53:362-8.
14. Leak LV, Ferrans VJ, Cohen SR, et al. Animal model of acute pericarditis and its progression to pericardial fibrosis and adhesions: ultrastructural studies. Am J Anat 1987;180:373-90.
15. Lefort B, El Arid JM, Bouquiaux AL, et al. Is Seprafilm valuable in infant cardiac redo procedures? J Cardiothorac Surg 2015;10:47-50.
16. Hasaniya N, Razzouk A, Newcombe J, et al. An absorbable hydrogel Spray Reduces Postoperative Mediastinal Adhesions After Congenital Heart Surgery. Ann Thorac Surg 2018;105:837-42.
17. Pace Napoleone C, Oppido G, Angeli E, et al. Resternotomy in pediatric cardiac surgery: CoSeal initial experience. Interact Cardiovasc Thorac Surg 2007;6:21-3.
18. Konertz WF, Kostelka M, Mohr FW, et al. Reducing the incidence and severity of pericardial adhesions with a sprayable polymeric matrix. Ann Thorac Surg 2003;76:1270-4.
19. Pace Napoleone C, Valori A, Crupi G, et al. An observational study of CoSeal for the prevention of adhesions in pediatric cardiac surgery. Interact Cardiovasc Thorac Surg 2009;9:978-82.

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