**Title**: Commentary: Sternotomy closure in high-risk patients: is Longitudinal Rigid Sternal Fixation the optimal approach?

**Running Head:** Longitudinal rigid sternal fixation in high risk patients

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**Text.**

The optimal technique for sternotomy closure for the prevention of sternal wound complications is a topic of unquestioned relevance to the cardiac surgical community. Given the wide range in the rates of morbidity and mortality in patients with sternal complications[1], and the 2008 Medicare policy change that deems deep sternal wound infection (DSWI) a “Never Event”[2], the pressing need for a consensus that delineates the optimal approach for sternal closure based on patient-specific preoperative characteristics in order to maximize patient safety is more urgent than ever. Innovative closure techniques have been developed including titanium cables[3], talon[4], flat wires[5,6], nitillium clips[7], and rigid plate fixation (RPF) [8,9]. As a result, there is a greater volume of approaches to sternotomy closure available but very little evidence to support the patient populations for whom these modalities would be appropriate.

Rigid plate fixation for sternotomy closure offers 1) sternal re-approximation and 2) rigid fixation to achieve optimal osteosynthesis compared to wire cerclage, which accomplishes sternal re-approximation only. Thus, RPF offers the advantage of enhanced mechanical stabilization and immobilization of the bone. Recent studies, including a multi-center randomized, controlled clinical trial demonstrated superior outcomes with sternotomy closure using RPF compared to CWC[10]. Reported results included improved sternal healing, reduced sternal complications, reduced postoperative pain, and improved quality of life out to 6 months[10]. These early results demonstrating reduced sternal wound complications, and their sequelae, make sternotomy closure using RPF a promising approach that may maximize patient safety[10]. However, it is important to note that this study excluded high-risk patients. Thus, it is unclear whether these results can be generalized to high-risk patients or specific phenotypes within the high-risk patient population. Furthermore, it must be recognized that the superior results seen with RPF may be attributed to the specific RPF device or technical approach used for placement in the study and should not be broadly applied to the wide variety of RPF devices and techniques currently available.

In this regard, Madjarov and colleagues[11] are commended for this report that adds to this important topic. The authors report the outcomes of their single-center experience using longitudinal rigid sternal fixation (LRSF) compared with conventional wire closure (CWC) for the prevention of sternal wound complications in high-risk patients only. The LRSF technique employs two longitudinal plates that distribute the force of wire closure evenly along the length of the sternum. In addition, the authors include the technical details and approach to reintervention for DSWI in 15 patients who underwent LRSF.

The authors found that LRSF offered a clear morbidity and mortality advantage over CWC, with reductions observed in DSWI (0.63% vs 3.45%), hospital length of stay (8.2 days vs 11.7 days), and 30-day mortality (1.57% vs. 5.96%). Moreover, LRSF was associated with lower pain scores on post-operative day 1 and on day of discharge, a key advantage given the increasing emphasis on minimizing narcotic use in post-operative pain management. Additionally, the LRSF plating system easily facilitated revision sternotomy in patients that underwent secondary operations, an important consideration for high-risk patients who are more likely to require reoperation.

Several key questions related to LRSF in high-risk patients remain. First, which sub-group of the high-risk patient population stands to benefit most from LRSF? Second, is follow up beyond 6 months necessary to evaluate implant failure in high-risk patients specifically?

Despite the promising results, there are several limitations to the study. Vessels used in CABG operations were not reported. Given that the use of BIMA in CABG operations in high-risk patients has been shown to be associated with a higher rate of sternal complications, differences in the proportion of patients who underwent CABG with BIMA between the compared groups may confound these outcomes [12–14]. Additionally, surgeon volume differed between the LRSF and CWC groups. A single-surgeon conducted all operations in the LRSF group compared to multiple surgeons in CWC group, which may introduce a confounding variable related to the operative approach in the CWC group. Lastly, while the authors used preoperative factors to identify high-risk patients, peri- and postoperative risk factors for sternal complications proposed in previous reviews[15,16] may have been present but were not evaluated.

In summary, DSWI and its sequalae are important targets for innovative approaches that mitigate the morbidity and mortality associated with sternal complications. This paper adds to growing evidence in support of LRSF[9,17–23] by demonstrating its utility in reducing DSWI, mortality, and post-operative pain in the high-risk population.

In our opinion, the easiest approach to reducing DSWI in patients undergoing cardiac surgery is to avoid a sternotomy. Although high-risk patients were an initial relative contraindication to the application of the robotic platform, recent studies have demonstrated excellent outcomes in a wide variety of high-risk patient populations when performed by experienced robotic surgeons[24–28]. The robotic platform should be considered for these patients and may play a growing role in preventing sternal complications in the high-risk patient population. If a sternal wound infection is a “Never Event”, then the only way to truly fulfill this mandate is by never performing a sternotomy.

**References**

[1] Abu-Omar Y, Kocher GJ, Bosco P, Barbero C, Waller D, Gudbjartsson T, et al. European Association for Cardio-Thoracic Surgery expert consensus statement on the prevention and management of mediastinitis. Eur J Cardiothorac Surg 2017;51:10–29. https://doi.org/10.1093/ejcts/ezw326.

[2] McNair PD, Luft HS, Bindman AB. Medicare’s Policy Not To Pay For Treating Hospital-Acquired Conditions: The Impact. Health Aff (Millwood) 2009;28:1485–93. https://doi.org/10.1377/hlthaff.28.5.1485.

[3] Dunne B, Murphy M, Skiba R, Wang X, Ho K, Larbalestier R, et al. Sternal cables are not superior to traditional sternal wiring for preventing deep sternal wound infection. Interact Cardiovasc Thorac Surg 2016;22:594–8. https://doi.org/10.1093/icvts/ivw017.

[4] Bennett-Guerrero E, Phillips-Bute B, Waweru PM, Gaca JG, Spann JC, Milano CA. Pilot study of sternal plating for primary closure of the sternum in cardiac surgical patients. Innov Technol Tech Cardiothorac Vasc Surg 2011;6:382–8. https://doi.org/10.1097/IMI.0b013e318248fbda.

[5] Boustany AN, Ghareeb P, Lee K. Prospective, randomized, single blinded pilot study of a new FlatWire based sternal closure system. J Cardiothorac Surg 2014;9:1–5. https://doi.org/10.1186/1749-8090-9-97.

[6] Soroff HS, Hartman AR, Pak E, Sasvary DH, Pollak SB. Improved sternal closure using steel bands: Early experience with three-year follow-up. Ann Thorac Surg 1996;61:1172–6. https://doi.org/10.1016/0003-4975(96)00025-2.

[7] Negri A, Manfredi J, Terrini A, Rodella G, Bisleri G, El Quarra S, et al. Prospective evaluation of a new sternal closure method with thermoreactive clips. Eur. J. Cardiothorac. Surg., vol. 22, Eur J Cardiothorac Surg; 2002, p. 571–5. https://doi.org/10.1016/S1010-7940(02)00411-6.

[8] Raman J, Lehmann S, Zehr K, De Guzman BJ, Aklog L, Garrett HE, et al. Sternal closure with rigid plate fixation versus wire closure: A randomized controlled multicenter trial. Ann Thorac Surg 2012;94:1854–61. https://doi.org/10.1016/j.athoracsur.2012.07.085.

[9] Allen KB, Thourani VH, Naka Y, Grubb KJ, Grehan J, Patel N, et al. Randomized, multicenter trial comparing sternotomy closure with rigid plate fixation to wire cerclage. J Thorac Cardiovasc Surg 2017;153:888-896.e1. https://doi.org/10.1016/j.jtcvs.2016.10.093.

[10] Allen KB, Thourani VH, Naka Y, Grubb KJ, Grehan J, Patel N, et al. Randomized, multicenter trial comparing sternotomy closure with rigid plate fixation to wire cerclage. J Thorac Cardiovasc Surg 2017;153:888-896.e1. https://doi.org/10.1016/j.jtcvs.2016.10.093.

[11] Madjarov J, Katz M, Fazal S. Use of Longitudinal Rigid Fixation in Prevention and Treatment of Wound Complications Among High-Risk Patients after Cardiac Surgery. J Card Surg n.d.

[12] Grossi EA, Esposito R, Harris LJ, Crooke GA, Galloway AC, Colvin SB, et al. Sternal wound infections and use of internal mammary artery grafts. J Thorac Cardiovasc Surg 1991;102:342–7.

[13] Dai C, Lu Z, Zhu H, Xue S, Lian F. Bilateral internal mammary artery grafting and risk of sternal wound infection: Evidence from observational studies. Ann Thorac Surg 2013;95:1938–45. https://doi.org/10.1016/j.athoracsur.2012.12.038.

[14] Zia A, Hasan M, Ilyas S, Siddiqui HU, Tappuni B, Marsia S, et al. Reining in Sternal Wound Infections: The Achilles’ Heel of Bilateral Internal Thoracic Artery Grafting. Surg Infect 2020;21:323–31. https://doi.org/10.1089/sur.2018.142.

[15] Balachandran S, Lee A, Denehy L, Lin KY, Royse A, Royse C, et al. Risk Factors for Sternal Complications After Cardiac Operations: A Systematic Review. Ann Thorac Surg 2016;102:2109–17. https://doi.org/10.1016/j.athoracsur.2016.05.047.

[16] Nenna A, Nappi F, Dougal J, Satriano U, Chello C, Mastroianni C, et al. Sternal wound closure in the current era: the need of a tailored approach. Gen Thorac Cardiovasc Surg 2019;67:907–16. https://doi.org/10.1007/s11748-019-01204-5.

[17] Pai S, Gunja NJ, Dupak EL, McMahon NL, Roth TP, Lalikos JF, et al. In vitro comparison of wire and plate fixation for midline sternotomies. Ann Thorac Surg 2005;80:962–8. https://doi.org/10.1016/j.athoracsur.2005.03.089.

[18] Pai S, Gunja NJ, Dupak EL, McMahon NL, Coburn JC, Lalikos JF, et al. A mechanical study of rigid plate configurations for sternal fixation. Ann Biomed Eng 2007;35:808–16. https://doi.org/10.1007/s10439-007-9272-3.

[19] Raman J, Song DH, Bolotin G, Jeevanandam V. Sternal closure with titanium plate fixation - A paradigm shift in preventing mediastinitis. Interact. Cardiovasc. Thorac. Surg., vol. 5, Oxford Academic; 2006, p. 336–9. https://doi.org/10.1510/icvts.2005.121863.

[20] Lee JC, Raman J, Song DH. Primary sternal closure with titanium plate fixation: Plastic surgery effecting a paradigm shift. Plast Reconstr Surg 2010;125:1720–4. https://doi.org/10.1097/PRS.0b013e3181d51292.

[21] Raman J, Straus D, Song DH. Rigid Plate Fixation of the Sternum. Ann Thorac Surg 2007;84:1056–8. https://doi.org/10.1016/j.athoracsur.2006.11.045.

[22] Snyder CW, Graham LA, Byers RE, Holma WL. Primary sternal plating to prevent sternal wound complications after cardiac surgery: Early experience and patterns of failure. Interact Cardiovasc Thorac Surg 2009;9:763–6. https://doi.org/10.1510/icvts.2009.214023.

[23] Marzouk M, Mohammadi S, Baillot R, Kalavrouziotis D. Rigid Primary Sternal Fixation Reduces Sternal Complications Among Patients at Risk. Ann Thorac Surg 2019;108:737–43. https://doi.org/10.1016/j.athoracsur.2019.03.046.

[24] Murphy DA, Moss E, Binongo J, Miller JS, Macheers SK, Sarin EL, et al. The Expanding Role of Endoscopic Robotics in Mitral Valve Surgery: 1,257 Consecutive Procedures. Ann Thorac Surg 2015;100:1675–82. https://doi.org/10.1016/j.athoracsur.2015.05.068.

[25] Murphy DA, Moss E, Miller J, Halkos ME. Repeat Robotic Endoscopic Mitral Valve Operation: A Safe and Effective Strategy. Ann Thorac Surg 2018;105:1704–9. https://doi.org/10.1016/j.athoracsur.2018.01.018.

[26] Ranganath NK, Loulmet DF, Neragi-Miandoab S, Malas J, Spellman L, Galloway AC, et al. Robotic Approach to Mitral Valve Surgery in Septo-Octogenarians. Semin Thorac Cardiovasc Surg 2020;32:712–7. https://doi.org/10.1053/j.semtcvs.2020.01.006.

[27] Loulmet DF, Ranganath NK, Neragi-Miandoab S, Koeckert MS, Galloway AC, Grossi EA. Advanced experience allows robotic mitral valve repair in the presence of extensive mitral annular calcification. J Thorac Cardiovasc Surg 2021;161:80–8. https://doi.org/10.1016/j.jtcvs.2019.10.099.

[28] Morbid Obesity does not Increase Morbidity or Mortality in Robotic Cardiac Surgery - Hiroto Kitahara, Brooke Patel, Mackenzie McCrorey, Sarah Nisivaco, Husam H. Balkhy, 2017 n.d. https://journals-sagepub-com.proxy1.lib.tju.edu/doi/10.1097/IMI.0000000000000435?url\_ver=Z39.88-2003&rfr\_id=ori:rid:crossref.org&rfr\_dat=cr\_pub%20%200pubmed (accessed February 12, 2021).