

DOI: 10.5455/msm.2022.34.142-148

Received: May 02 2022; Accepted: Jun 14, 2022

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ORIGINAL PAPER

Mater Sociomed. 2022 Jun; 34(2): 142-148

Our Experiences in the Treatment of Anterior Chest Wall Infections (2015 - 2021)

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ABSTRACT

Background: Sternotomy is a classical surgical procedure for approaching the heart and mediastinum. Sternotomy wound infections can be superficial or deep. **Objective:** The aim of this study is to retrospectively evaluate the results of two treatments for deep sternal wound infection (DSWI), closed treatment (debridement, refixation and retrosternal irrigation) and open treatment (debridement, VAC therapy and then pectoral flap). **Methods:** Retrospective analysis of two methods of treatment of DSWI in the period of six years. The first group (G1): surgical debridement, sternum fixation with, if necessary, retrosternal irrigation. The second group (G2): surgical debridement, open sternum with VAC therapy and subsequent pectoral flap with sternum refixation if necessary. Sternotomy wound infection will be classified according to the depth of the affected areas and the time of infection. Risk factors, outcome, local findings, number of revisions, number of hospital treatment days, types of isolates, etiology of sternotomy, time from onset of sternal instability to first surgical treatment will be observed. **Results:** The number of patients with DSWI was 16, which represents 1% of all sternotomy in the observed period. Mortality in the DSWI group was 35%. Surgical myocardial revascularization was initially performed in 73% of patients with DSWI. Two risk factors for DSWI were in 32% of patients and 25% had diabetes mellitus. The average time for DSWI development in G1 was 10 days (min 0, max 30) and in G2 was 20 days (min 12, max 30). Number of revisions in G1 (min 1, max 2), G2 (min 1, max 3). Average number of hospital days were in G1 23.50 days (SD 13.15), and in G2 38.17 days (SD 28.65). The sternum was osteomyelitic and fragmented in 20% of patients. More than one revision occurred in 40% of patients.

The main initial isolate was *Enterococcus faecalis* in 27% of all DSWI (dominantly in G1 2/3 of all):

Conclusion: We found that there is no statistically significant difference in observed treatments, and that each treatment has its own indications. We suggested that studies with a larger sample are needed for a definite opinion on this issue.

Keywords: Sternotomy, Deep Sternal Wound Infection (DSWI), Anterior Chest Wall Infections, VAC Therapy.

1. BACKGROUND

Sternotomy is a classical surgical procedure for approaching the heart and mediastinum. Sternotomy wound infections can be superficial or deep. Deep sternal wound infection (DSWI) means infection of deep structures, ie. fascia and structures below fascia. Such infections correspond to postoperative mediastinitis. By definition, at least one sign must be present for DSWI: local sign of infection or spontaneous dehiscence of the sternum, purulent discharge from the wound, isolated bacterial causative agent from the mediastinum, wound pain and sternum instability and/or sternal click with temperatures above 38°C. In addition, imaging (CT or X-ray) may show signs of retrosternal or bone infection with hemisternal dislocation. DSWI is a life-threatening complication with an incidence of 0.5–6% (9). It is associated with high mortality (10–47%¹) and morbidity and prolong hospitalization (15–30 days).

There are many risk factors for developing DSWI typically divided into patient and peri-operative ones. The main patient risk factors are: diabetes, overweight, COPD, female gender, chronic renal failure, osteoporosis. Patient risk

factors are cumulative, therefore, their early recognition is mandatory. The main perioperative risk factors are: inadequate skin disinfection, duration of operation, bilateral IMA harvesting, IMA with pedicle or disconnection IMA after bifurcation, urgent surgery.

The most common isolates in DSWI are: Staphylococcus aureus, Coagulase-negative Staphylococcus (CoNS), less common are: Propionibacterium, Acinetobacter, Enterobacter cloacae, Escherichia coli, Klebsiella, Pseudomonas aeruginosa, Acinetobacter baumannii, Proteus mirabilis.

There are several DSWI classification systems: El-Oakley & Wright (1996) based on time to develop and risk factors for DSWI, Rupprecht & Schmid (2013) based on sternal stability and local infection findings, Pairolero & Arnold (1984) based on timing for DSWI development and Greig (2007) based on sternal segment affected (useful for flap selection). Pairolero and Arnold classification is clinically useful because it is generally believed that the later the DSWI occurs, the greater the chance for stability of the anterior chest wall and thus easier treatment. According to mentioned, the most challenging treatment is in middle form or so-called fulminant mediastinitis where sternal dehiscence develop in first few weeks, usually 2-3 weeks.

Types of DSWI treatment

DSWI treatment evolved over the years, and the modern approach includes conservative and surgical measures. It must be aggressive immediately at admission and its aim is to: eradicate the infection, stabilize the chest wall and cover any cavities or defects.

Conservative treatment include preventive measures such as systematic swabs before surgery, disinfection of patients skin upon arrival at the hospital, also include specific intraoperative techniques: strict medial sternotomy, preventive hemisternal wire reinforcement in osteoporotic sternums, gentle tissue handling, frequent disinfection of the operative wound, avoidance of opening of pleural cavities, harvesting internal mammary artery above bifurcation, avoidance of bilateral internal mammary artery use in high-risk patients, use of incisional VAC.

Fighting the infection involves long-term (eg. in osteomyelitis it last 6 weeks) combined antibiotic therapy (first ex juvantibus later according to the swab) and surgical treatment (generous surgical debridement off all necrotic tissue and removal of all exposed wires. Additionally, fighting infection is done by retrosternal irrigation (if sternum re-fixation is possible), VAC therapy, muscle or omentum transposition (according to local availability), and partial or complete sternectomy.

Stabilization of the sternum can be achieved by rewiring, with lateral reinforcement, Robiscek technique or use of sternal plates also with filling of the cavity with muscle flap, also active VAC system can stabilize anterior chest wall.

Retrosternal irrigation

Retrosternal irrigation is performed via two Redon tubes placed jugulary (via perfusomat: 0.5 ml/h of 0.05% heated iodine solution) and via two chest tubes placed retrosternally for aspiration using classical Thoracic vacuum system. Retrosternal irrigation is especially effective in retrosternal soft tissue infections, but not in osteomyelitis due to poor penetration into bone. In general duration of retrosternal

irrigation should be around 7 days.

VAC therapy

VAC therapy for DSWI treatment is a method in which the use of vacuum helps to heal a wound. The use of vacuum therapy involves the use of a polyurethane sponge with pores of half a millimeter, occlusive foil, fluid aspiration catheters, reservoirs and negative pressure systems. Wound cavity is continuously or intermittently exposed to negative pressure which is generated by special portable devices. The advantage of VAC therapy is the ability to continuously remove exudates and bacteria from the wound while stabilizing the chest wall and isolating the wound from surrounding environment. VAC therapy enhances granulation and vascularization, with increased parasternal blood flow, eliminates dead space and patients can be mobilized earlier (if a portable system is used).

Use of VAC is simple but attention must be paid to detail. First the sponge must be cut according to the size and shape of the wound cavity, in one piece. In the case of deep wounds, the second sponge can be used. Extremely rarely when severe dehiscence and destruction of the sternum are present at time less than 3 weeks, where there is no fibrous tissue over the heart, a third layer of vaseline like protection is placed over the heart and aorta or dedicated film sponge. At the top a self-adhesive transparent foil with a valve for vacuum line is placed over, covering widely surrounding skin. Sometimes, in the absence of original VAC systems, various aspiration catheters are used, over mentioned sponge. Also in some institutions, given the cost of portable devices, a vacuum is improvised over the wall vacuum system, as well as using pre-sterilized sponges for other purposes. Unfortunately, some sponges do not have an adequate pore size, which are significantly smaller (up to 100 times in surgical hand wash sponges). For this reason, their use can be problematic, since after a few hours there is a partial clogging of the pores at the bottom of the wound. Since re-dressings are performed every 2-4 days¹⁰ the edges of the foil and the catheter are reinforced with wide strong adhesive plasters (eg. 3M). After covering of the wound, the original valve or any used catheter from the wound cavity is connected to the vacuum system on the original device or to the wall vacuum. Both systems must have an unloading bottle for fluid collection, especially for wall systems in order to avoid contamination of vacuum installations. A continuous (may impair microcirculation) or intermittent vacuum (5 minutes on, 2 minutes off) with a negative pressure of 50 to 250 mmHg is used, ideally 75-100-125 mmHg. Dressing is better to be perform in OR if additional debridement is needed. The size of the wound and the appearance of granulation are monitored during each re-dressing. Swabs are usually taken weekly and body temperature, CRP and leukocyte count are monitored daily.

The decision to finish VAC therapy is based on the general condition of the patient and local wound findings (wound size and granulation), normalization of leukocyte count and inflammatory factors (CRP <40-60) and eradication of the causative agent (negative wound wipe). For VAC according to modern recommendations duration should be short as possible (<4 days) because complications are more common with prolonged VAC treatments. For severely ill patients

	G1 (without VAC)		G2 (with VAC)		Total	
Gender	M 8 (72%)	F 1 (28%)	M 2 (33%)	F 4 (66%)	M 10 (66%)	F 5 (33%)
Age	Mean 68 (SD 9)		Mean 64 (SD 4)		Mean 66 (SD 6)	
Type of initial operation	No	%	No	%	No	%
CABG	4	36%	7	64%	11	73%
Non CABG	2	100%	0	0%	2	13%
CABG + aortic valve	2	100%	0	0%	2	13%
Total	8		7		15	100%
DSWI risk factors	No	%	No	%	No	%
Weight (>BMI)	2	66%	1	33%	3	9
Diabetes Melitus	2	25%	6	75%	8	25
Female	1	14%	6	86%	7	21
COPD	1	50%	1	50%	2	6
PVD	2	100%	0	0%	2	6
Miscellaneous	10	100%	0	0%	10	31
Total	18	56%	14	44%	32	100
2 risk factors	6	50%	6	50%	12	37%
Initial pathogenic bacteria	No	%	No	%	No	%
Enterococcus faecalis	4	66%	2	33%	6	27%
Stenotrophomonas maltophilia	1	100%	0	0%	1	4.5%
Pseudomonas species	1	100%	0	0%	1	4.5%
Staphylococcus epidermidis	1	100%	0	0%	1	4.5%
MRSA	2	100%	0	0%	2	9%
Serratia marezens	1	50%	1	50%	2	9%
E. coli	1	100%	0	0%	1	4.5%
Proteus mirabilis	0	0%	2	100%	2	9%
Citrobacter freundii ESBL	0	0%	1	100%	1	4.5%
Acinetobacter baumannii	0	0%	1	100%	1	4.5%
Klebsiella pneumoniae ESBL	0	0%	3	100%	3	13%
Pseudomonas aeruginosa	1	100%	0	0%	1	4.5%
Total	12	54%	10	46%	22	100%
No isolates > than 1	4	57%	3	43%	7	31%
Days before revision	Mean 10.67 (0-30)		Mean 20 (12-30)			
Days of hospitalization	Mean 23.50 (SD 13.15)		Mean 38.17 (SD 28.65)			
Local findings	No		No		Total	
Sternum preserved, exposed wires	9		3		12	
Sternum osteomyelitis fragmented	0		3		3	
Total	9		6		15	
Number of revision	No		No		Total	
One	7		2		9	
Two	2		2		4	
Three	0		2		2	
Total	9		6		15	
Outcome	No		No		Total	
Alive	6		3		9	
Exitus	2		3		5	
Total	8		6		14	

Table 1. The sample of the study investigated during research - M - Male, F - Female

who probably will not survive flap surgery we have to plan long VAC period finishing with skin sutures (all other will get flap as early as possible).

The pectoral flap can cover the wound and fill the cavity of the sternum (in cases of a partial/full sternectomy). The pectoral unilateral sliding flap proved to be simple, readily available and the best option. Bilateral pectoralis muscle can be used for tension prevention. But, when pectoralis tendon is cut and muscle is overturned bilateral flaps have large operative wound and cause mutilation (authors no longer use it). For lower half of the wound cavity we can use the rectus abdominus muscle. During flap covering, two Redon tube are placed in the medial line over sternum and one over and below the muscle itself. The muscle (with immersion of the edge of the muscle in the cavity of the sternal defect) is fixed to the contralateral fascia or to the remains of the ribs with interrupted sutures. Redon tubes under the flap are removed when daily drainage is below 5-15ml (It usually takes 2-3 weeks). The skin and subcutaneous tissue over flap are closed with interrupted sutures in one or two layers. Over closed wound incisional VAC can be placed. Postoperatively fixation of the breast should be performed to the contralateral with a wide tape (10 cm, from the middle to the middle axillary line) or for the contralateral shoulder. The arm is fixed to the body for 24-48 hours, then the arm is allowed to move, but without abduction and lifting the body with the arms.

A special type of VAC therapy is the so-called incisional VAC. In high-risk patients, the VAC system is preventively placed on the skin after closing the operative wound. Redressing is performed on every second day with duration of treatment of 9-10 days. This treatment achieves cavity obliteration, removal of clots and eventually bacteria and better blood circulation.

2. OBJECTIVE

The aim of this study is to retrospectively evaluate the results of two treatments for deep sternal wound infection (DSWI), closed treatment (debridement, refixation and retrosternal irrigation) and open treatment (debridement, VAC therapy and then pectoral flap).

3. MATERIAL AND METHODS

Retrospective analysis of two methods of treatment of DSWI in the period of six years. The first group (G1): surgical debridement, sternum fixation with, if necessary, retrosternal irrigation. The second group (G2): surgical debridement, open sternum with VAC therapy and subsequent pectoral flap with sternum refixation if necessary. Sternotomy wound infection will be classified according to the depth of the affected areas and the time of infection. Risk factors, outcome, local findings, number of revisions, number of hospital treatment days, types of isolates, etiology of sternotomy, time from onset of sternal instability to first surgical treatment will be observed.

4. RESULTS

Over a five-year period, we had 16 patients with DSWI at the Clinic for cardiovascular surgery. In that period, 1600 patients were operated using sternotomy approach, indi-

cating incidence of DSWI as 1%. We compare two groups of patients, those who were not treated with VAC therapy (sternal refixation and retrosternal irrigation) (G1) and those who were treated with VAC therapy (VAC and later flap coverage) (G2), we had the following results.

5. DISCUSSION

There are several therapeutic strategies for DSWI treatment, where early recognition and antibiotic therapy along with urgent surgical treatment of the wound is crucial and there is no discussion about it. Usually, in the initial DSWI treatment, mechanical and chemical debridement is performed under general anesthesia (all necrotic content and osteosynthetic material were removed; the wound is repeatedly and thoroughly washed with iodine and hydrogen peroxide). In the early form (Type I of Pairolero and Arnold classification), the primary goal is to stabilize the chest wall. Since there are often no signs of osteomyelitis and sternal maceration nor retrosternal abscess or intense secretion we perform only sternal refixation without retrosternal irrigation. But, we encourage its use because of its simplicity and potentially great benefit. If there is second form (Type II) we have to fight both the infection and the instability of the chest wall. So, after surgical debridement before sternal refixation (if there are no local signs of osteomyelitis) retrosternal irrigation is mandatory. More recently, for this stage, muscle flap coverage is recommended. If the local finding does not allow refixation of the sternum, VAC therapy is performed and a subsequent muscle flap is planned. In case of the third form (Type III), the primary goal is to fight chronic infection by surgical debridement, extraction of all wires and close wound over a Redon tube. VAC therapy or muscle flap is rarely required.

According to our results, related to the age of patients, statistically there was no significant differences in groups ($t = 0.985$, Sig 0.369). According to the literature, there are slightly younger patients with the DSWI, with mean of 53 years⁹. Also in this table the gender distribution over G1 and G2 shows that there is no statistically significant correlation between gender and G1/G2 (Fisher exact test, Sig = 0.89), although there are slightly more females in G2. But, overall there we found 2/3 men vs. 1/3 women as in other studies.

We found that surgical myocardial revascularization (CABG) was dominant initial surgical procedure in all DSWI. Probably, because the risk factors for ischemic heart disease overlap with the risk factors for DSWI.

We found that two dominant bacteria detected in DSWI were *Enterococcus faecalis* and *Klebsiella pneumoniae* ESBL. In the literature, the main and most common isolate is *Staphylococcus aureus*, which is very difficult to treat. In our sample, *Staphylococcus aureus* was in 3rd place. Also at Thoracic surgery department KCUS the most common wound isolates were *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Also we had multiple isolates in 1/3 of the patients.

The local findings influenced the decision on the type of treatment. Thus, according to the results, we see that patients with osteomyelitis and multiple fragmented sternum were treated with VAC with subsequent flap. Some patients with locally preserved sternum were treated in this way,

probably according to the operator's assessment that the wounds were very dirty. According to the above results, there is a statistically significant correlation between the local finding and the used operational technique (Fisher exact test), $\text{Sig} = 0.044$, with a moderately strong correlation between Cramers $V = 0.612$. Some authors in case of dirty wounds recommend a period of VAC therapy (unredressing it) with delayed wound closure after 3x sterile swabs while others look mainly on local findings. According to our results, before new recommendations we tend to close sternotomy wounds quite late after VAC, waiting for granulations and a series of negative swabs. Now, we tend to closure of the wound as early as possible after VAC, preferably within 7 days. We noticed, although we did not show in the results of this paper, that patients waiting for the wound to be microbiologically clean, and granulations to cover entire wound entered in a protein deficit that is extreme in all patients with complications and often end lethal. Also, in some patients the systemic inflammation parameters were normalized, locally the wound was clean without discharge but a positive swab arrived again and again. According to recently published papers, there is evidently better success in early coverage of the wound with flap in one act or as soon as possible in VAC cases, in addition to the obligatory aggressive antibiotic treatment. Therefore, we believe that in hospitalized patients and other whose wound is not dirty (fistula with pus, very dirty on revision, a necrotic or multiple fragmented sternum, hemodynamically unstable patient) the wound should be closed immediately in one act. If the wound is neglected, it is necessary to postpone the closure and flap for a maximum of 4-7 days. Until then, after debridement, the wound should be left open with the placement of VAC and intravenous antibiotics. The importance of early definitive closure is shown by the fact that mortality is twice as low in closure in 1 to 3 days than in 4 to 7 days from the diagnosis of DSWI. Not to mention a larger number of reinterventions, prices, etc. We would here emphasize treatment of severe DSWI in one act, it includes mechanical and chemical debridement, retrosternal irrigation, sternal re-fixation, and pectoral flap. Our position was in line with the term "flap fixation". Where the wires are placed again with the obligatory covering with a flap, which results in better stability of the front wall of the chest and quality of life if the bone is preserved as much as possible. But, for this approach the literature and properly randomized studies should be additionally followed, because there is a dilemma whether in the case of a dirty wound that is covered with VAC after debridement, wires should be placed at all at the final revision.

Also in patients from G1 were treated during initial hospitalization while G2 patients were treated in the second hospitalization when severe DSWI was observed. Mean DSWI onset time for both groups was 10 and 20 days (table 1) from the initial operation. The onset time of DSWI in the literature is 25.8 day, with two subgroups early and late⁹.

Regarding the number of days of hospitalization, there is statistically no significant differences in G1/G2 groups ($t = -1.290$, $\text{Sig} 0.221$). The median time after G2 treatment is 38 days and is much longer than the literal data of 21 days². Although there are papers that show such long hos-

pital treatments as well. As our experience improve we try to decrease VAC days and now we are trying to keep the VAC for a maximum of 3-7 days, if the local findings allow it, due to new recommendations. So, we expect shorter hospital stays in G2 in the future. The mean duration of hospitalization in G1 is 23 days, which is in reality even less because the days from arrival to the initial operative procedure are included here.

Our overall mortality was about 30%, but there was no statistically significant association between outcome and local findings. This indicates the existence of a number of other factors that deplete patients' biological reserves during long-term hospitalizations. We think that hypoproteinemia which was present in our patients is one of the most important factors in healing DSWI. Also, such a high mortality compared to the literature¹¹ (10-15%) is probably due to incorrect treatment and neglected patients treated in outpatient medical facilities. Namely, all patients from G2 were admitted to the hospital after a period of outpatient treatment and not by a surgeon. Although there are series with high mortality as in our data set.

The number of revisions is slightly higher as we approach more complex modalities of operative wound treatment, given that they are certainly reserved for more severe forms of DSWI. In the literature, the number of revisions ranges from one (61.5%) to three (11.5%)⁹. The use of VAC with subsequent flap is reserved for dirtier wounds that are difficult to heal by themselves and sometimes have to be revised several times. But, according to our results, this increase is not statistically significant as there is no correlation between the number of revisions and the operational technique used Fisher exact test = 3.896, $\text{Sig} = 0.103$.

According to our results, although we had a rather small sample, we did not find a statistically significant correlation between outcomes and operational techniques used (G1 or G2) Fisher exact test, $\text{Sig} = 0.580$.

6. CONCLUSION

DSWI is a life-threatening complication after cardiac surgery. Although rare, mortality, morbidity and treatment costs are very high and treatment should be approached very aggressively with immediate revision. Taking preventive measures in high-risk patients is important. It is good practice to perform CT of the thoracic organs immediately after diagnosing DSWI.

We believe that the following views can be emphasized. Primarily, ex-juvantibus and directed aggressive antibiotic therapy in consultation with an infectologist. An urgent consultation with a plastic surgeon and presence at the initial debridement is required for flap selection and possible sternum fixation. The goal is to cover wound with flap early, and if that is not possible due to instability, to set the VAC as short as possible until definitive closure with flap.

We believe that there is no difference between the operational techniques used (G1 and G2), ie. each technique has its own indications. Thus, VAC treatment is reserved for heavily contaminated wounds as well as those patients who are hemodynamically unstable to be candidates for sternum re-fixation. All other patients should be closed immediately with retrosternal irrigation.

- **Author's contribution:** All authors were involved in the preparation of this article. Final proofreading was made by the first author
- **Conflict of interest:** None declared.
- **Financial support and sponsorship:** Publishing fee supported by Sors.d.o.o, Banjaluka, Bosnia and Herzegovina.

REFERENCES

- Singh K, Anderson E, Harper JG. Overview and management of sternal wound infection. *Semin Plast Surg.* 2011 Feb;25(1):25-33. doi: 10.1055/s-0031-1275168
- Hever P, Singh P, Eiben I, Eiben P, Nikkhah D. The management of deep sternal wound infection: Literature review and reconstructive algorithm. *JPRAS Open.* 2021 Mar 6;28:77-89. doi: 10.1016/j.jpra.2021.02.007
- Grapow M, Haug M, Tschung C, Winkler B, Banerjee P, Heinsch P, et al. Therapy options in deep sternal wound infection: Sternal plating versus muscle flap. *PLoS One.* 2017 Jun 30;12(6). doi: 10.1371/journal.pone.0180024
- Masic I, Begic E. Meta-analysis as Statistical and Analytical Method of Journal's Content Scientific Evaluation. *Acta Inform Med.* 2015 Feb;23(1):4-11. doi: 10.5455/aim.2015.23.4-11.
- Song F, Liu Z. Bilateral-pectoral major muscle advancement flap combined with vacuum-assisted closure therapy for the treatment of deep sternal wound infections after cardiac surgery. *J Cardiothorac Surg.* 2020 Aug 27;15(1):227. doi: 10.1186/s13019-020-01264-2
- Rashed A, Gombocz K, Alotti N, Verzar Z. Is sternal rewiring mandatory in surgical treatment of deep sternal wound infections? *J Thorac Dis.* 2018 Apr;10(4):2412-2419. doi: 10.1186/1749-8090-6-112
- Granov N, Kacila M, Mujic E, Hadzimehmedagic A, Custovic F, et al. Kubic M. V-type mini sternotomy in aortic valve replacement. *Med Arch.* 2012;66(3):213-4. doi: 10.5455/medarh.2012.66.72-78.
- Sears D, Momoh O, Chung C, Lu T, Zhong L, Waljee F. A National Study of the Impact of Delayed Flap Timing for Treatment of Patients with Deep Sternal Wound Infection. *Plast Reconstr Surg.* 2017 Aug;140(2):390-400. doi: 10.21037/jtd.2019.12.76
- Pan T, Li K, Fan D, Gao S, Wang J. Vacuum-assisted closure vs. bilateral pectoralis major muscle flaps for deep sternal wounds infection. *J Thorac Dis.* 2020 Mar;12(3):866-875. doi: 10.21037/jtd.2018.03.166
- Hämäläinen E, Laurikka J, Huhtala H, Järvinen O. Vacuum assistance therapy as compared to early reconstructive treatment in deep sternal wound infection. *Scand J Surg.* 2021 Jun;110(2):248-253. doi: 10.1177/1457496920979289
- Lo F, Turriziani G, Donato C, Marcasciano M, Redi U, Greco M, et al. Deep sternal wound infection following cardiac surgery: A comparison of the monolateral with the bilateral pectoralis major flaps. *Int Wound J.* 2020 Jun;17(3):683-691. doi: 10.1111/iwj.13324
- Avdic S, Osmanovic E, Kadric N, Mujanovic E, Ibisevic M, Avdic A. Time of Occurrence and Duration of Atrial Fibrillation Following Coronary Artery Bypass Grafting. *Med Arch.* 2016 Apr;70(2):97-100. doi: 10.5455/medarh.2016.70.97-100.
- Karic A, Mujanovic E, Karic A, Jerkic Z, Bergsland J, Kabil E. Results of coronary bypass grafting in treatment of left main stenosis. *Med Arh.* 2009;63(6):328-31.
- Granov D, Ljubovic AD, Zec SL, Granov N, Hukic M. The Impact of Antibiotic Consumption on Development of *Acinetobacter Baumannii* Resistance. *Mater Sociomed.* 2016 Dec;28(6):449-453. doi: 10.5455/msm.2016.28.449-453.
- Lukovac E, Koluder CN, Hadzovic CM, Baljic R, Hadzic A, Gojak R. Analysis of Comorbidity of the Patients Affected by Staphylococcal Bacteremia/Sepsis in the Last Ten Years. *MATSOCMED:2012-;* 24-1: 13-15. doi:10.5455/msm.2012.24.s13-s15
- Aksamija G, Mulabdic A, Rasic I, Aksamija L. Evaluation of Risk Factors of Surgical Wound Dehiscence in Adults After Laparotomy. *Med Arch.* 2016 Oct;70(5):369-372. doi:10.5455/medarh.2016.70.369-372.
- Salihovic AA, Salihovic E, Kadric N, Ibisevic M, Avdic S. Successful Treatment of Cardiac Tamponade with Corticosteroids After Surgical Myocardial Revascularization: Case Report. *Med Arch.* 2018 Oct;72(4):285-288. doi: 10.5455/medarh.2018.72.285-288.
- Granov N, Kacila M, Solinas M, Glauber M. Minimally invasive mitral valve surgery through right lateral minithoracotomy--early experience of Clinical Centre of University of Sarajevo. *Med Arch.* 2012;66(5):357-8. doi: 10.5455/medarh.2012.66.357-358.
- Djedovic S, Mujanovic E, Djedovic M, Rajkovic S, Jahic M, Tomic Z. Surgical revascularization in elderly patients with and without cardiopulmonary bypass. *Med Arch.* 2013;67(5):351-3. doi: 10.5455/medarh.2013.67.351-353.
- Phoon Y, Hwang C. Deep Sternal Wound Infection: Diagnosis, Treatment and Prevention. *J Cardiothorac Vasc Anesth.* 2020 Jun;34(6):1602-1613. doi: 10.1053/j.jvca.2019.09.019.
- Mujanovic E, Bergsland J, Jahic M, Djedovic S, Behrem A, Stanimirovic-Mujanovic S, et al. Bloodless off pump coronary artery bypass grafting treatment of choice for Jehovah's witness patients. *Med Arh.* 2012;66(2):140-2. doi: 10.5455/medarh.2012.66.140-142.
- Baillet R, Cloutier D, Montalin L, Cote L, Lellouche F, Houde C, et al. Impact of deep sternal wound infection management with vacuum-assisted closure therapy followed by sternal osteosynthesis: a 15-year review of 23,499 sternotomies. *Eur J Cardiothorac Surg.* 2010 Apr;37(4):880-7. doi: 10.1016/j.ejcts.2009.09.023.
- Wang C, Zhang J, Liu Z. Vacuum-assisted closure therapy combined with bi-pectoral muscle flap for the treatment of deep sternal wound infections. *Int Wound J.* 2020 Apr;17(2):332-338. doi: 10.1111/iwj.13277.
- Pan T, Li K, Fan FD, Gao YS, Wang DJ. Vacuum-assisted closure vs. bilateral pectoralis major muscle flaps for deep sternal wounds infection. *J Thorac Dis.* 2020 Mar;12(3):866-875. doi: 10.21037/jtd.2019.12.76.
- Mujanovic E, Bergsland J, Tursic A, Stanimirovic-Mujanovic S, Kabil E. Coronary bypass grafting without use of cardiopulmonary bypass for dextrocardia. *Med Arh.* 2011;65(1):56-7.
- Tewarie L, Moza K, Khattab A, Autschbach R, Zayat R.. Effective Combination of Different Surgical Strategies for Deep Sternal Wound Infection and Mediastinitis. *Ann Thorac Cardiovasc Surg.* 2019 Apr 20;25(2):102-110. doi: 10.5761/atcs.oa.18-00115.
- Kaul P. Sternal reconstruction after post-sternotomy mediastinitis. *J Cardiothorac Surg.* 2017 Nov 2;12(1):94. doi: 10.1186/

- s13019-017-0656-7.
28. Repossini A, Dossena T, D'Alonzo M, Stara A, Rosati F, Muneretto C. Surgical treatment of mediastinitis: The vertical bolstered Donati stitch. *Multimed Man Cardiothorac Surg.* 2021 Jan 20;2021. doi: 10.1510/mmcts.2021.003.
 29. Lukovac E, Koluder CN, Hadzovic CM, Baljic R, Ahmetspahic BA. Staphylococcal sepsis and frequency of metastatic foci. *Med Arch.* 2012;66(3 Suppl 1):48-50.
 30. Juhl A, Hody S, Videbaek S, Damsgaard TE, Nielsen PH. Deep Sternal Wound Infection after Open-Heart Surgery: A 13-Year Single Institution Analysis. *Ann Thorac Cardiovasc Surg.* 2017 Apr 20;23(2):76-82. doi: 10.5761/atcs.oa.16-00196.
 31. Karabdic I, Hasanovic A, Kabil E, Straus S. Improvement of ejection fraction after coronary artery bypass grafting surgery in patients with impaired left ventricular function. *Med Arch.* 2014 Oct;68(5):332-4. doi: 10.5455/medarh.2014.68.332-334..
 32. Piwnica W, Azoury C, Kozak G, Nathan S, Stranix JT, Colen D. Flap Reconstruction for Deep Sternal Wound Infections: Factors Influencing Morbidity and Mortality. *Ann Thorac Surg.* 2020 May;109(5):1584-1590. doi: 10.1016/j.athoracsur.2019.12.014.
 33. Kamel N, Jacobson J, Rizzo M, Kinkhabwala C, Lalezar F, Draper L. Analysis of Immediate versus Delayed Sternal Reconstruction with Pectoralis Major Advancement Versus Turnover Muscle Flaps. *J Reconstr Microsurg.* 2019 Oct;35(8):602-608. doi: 10.1055/s-0039-1688760.
 34. Barbera F, Lorenzetti F, Marsili R, Lisa A, Guido G, Pantaloni M. The Impact of Preoperative Negative-Pressure Wound Therapy on Pectoralis Major Muscle Flap Reconstruction for Deep Sternal Wound Infections. *Ann Plast Surg.* 2019 Aug;83(2):195-200. doi: 10.1097/SAP.0000000000001799.
 35. Song F, Liu Z. Bilateral-pectoral major muscle advancement flap combined with vacuum-assisted closure therapy for the treatment of deep sternal wound infections after cardiac surgery. *J Cardiothorac Surg.* 2020 Aug 27;15(1):227. doi: 10.1186/s13019-020-01264-2.
 36. Zhang H, Lin J, Yang H, Pan Y, Chen L. Bilateral partial pectoralis major muscle turnover flaps for the management of deep sternal wound infection following cardiac surgery. *J Thorac Dis.* 2020 Oct;12(10):6010-6015. doi: 10.21037/jtd-20-2845.
 37. Karic A, Haxhibeqiri I, Kabil E, Grabovica S, Straus S, Busevac E, et al. Left Ventricular Free Wall Rupture After Acute Myocardial Reinfarction Due to In-Stent Thrombosis in COVID-19 Patient. *Acta Inform Med.* 2022 Mar;30(1):76-80. doi: 10.5455/aim.2022.30.76-80.
 38. Arsalan A, Dick L, Arsalan M, Wölflle O, Walther T, Sauerbier M. Impact of microbial findings on plastic reconstructive surgery outcomes in patients with deep sternal wound infection after cardiac surgery. *J Plast Surg Hand Surg.* 2020 Jun;54(3):182-186. doi: 10.1080/2000656X.2020.1738240.
 39. Ivanzov S, Soynov I, Kulyabin Y, Zubritskiy A, Zubritskiy A, Voitov A, Omelchenko A. Vacuum-assisted closure versus closed irrigation for deep sternal wound infection treatment in infants: a propensity score-matched study. *Interact Cardiovasc Thorac Surg.* 2019 Nov 1;29(5):776-782. doi: 10.1093/icvts/ivz167.
 40. Begic E, Arnautovic A, Masic I. Assessment of risk factors for diabetes mellitus type 2. *Mater Sociomed.* 2016 Jun;28(3):187-90. doi: 10.5455/msm.2016.28.187-190.