

Treatment algorithm for post sternotomy wound infection – our experience

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Summary

Introduction: Median sternotomy is the most commonly used approach in open cardiac surgery. As in any other surgery, surgical site infections are a known phenomenon, but morbidity depends on the depth of infection. Superficial wound infections can be managed conservatively; however, deep sternal wound infections need an aggressive approach to prevent disastrous consequence like mediastinitis. Hence, this study was conducted with the aim to classify sternotomy wound infection and to develop a treatment algorithm for superficial and deep sternotomy wound infections. **Material and methods:** Between January 2016 to August 2021, 25 patients who had sternotomy wound infections were studied. These wound infections were classified as superficial or deep sternal wound infections. **Results:** Superficial wound infections underwent treatment with diluted vinegar dressings and deep infections underwent treatment with bilateral pectoralis major muscle advancement flaps. Patients were followed up till the wounds healed completely without complications. Patient characteristics, comorbidities, duration of treatment and outcomes of treatment were analyzed. Superficial sternal wound infection patients responded favorably to diluted vinegar dressings and deep sternal wound infection patients to pectoralis major muscle advancement flaps. Average time duration of healing for superficial and deep wound infections was 66.2 days and 18 days respectively. None of the patients had an increased severity of infection or re-dehiscence following treatment and during follow-up. **Conclusion:** Relatively conservative approach using diluted vinegar (1% acetic acid) dressing for superficial sternal wound infections was efficacious, whereas aggressive debridement and bilateral pectoralis major advancement muscle flaps for deep sternal wound infections are necessary for favorable outcomes. However, more studies are needed to ascertain this treatment algorithm.

Key words

open heart surgery – superficial sternal wound infection – deep sternal wound infection – 1% acetic acid – pectoralis major flap

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Introduction

Over 90,000 cardiac surgeries are performed in the United States alone every year and the number is increasing at 5% per year [1]. In India, approx. 15,000 surgeries are performed per year. Median sternotomy introduced by Schumacher and Lure [2] is the most commonly used incision in open heart surgeries [3]. The 1–3% incidence of surgical site infections (SSI) have been observed in USA. Various factors can lead to sternal wound infection. These include old age, comorbidities such as diabetes, hypertension, high body mass index, and chronic obstructive pulmonary disease. Sternal wound infection developing into deep sternal wound infection (DSWI) increases the mortality and morbidity. Dif-

ferent studies have documented varied incidence of DSWI from 2% up to 47% [4]. Although infection rates are low, the severity of the infection determine the patient's morbidity and mortality.

Superficial sternal wound infection can be conservatively managed with regular wound dressings, debridement, and secondary suturing. However, one of the most important steps in the management of deep sternal wound infections is obliteration of a dead space. This is achieved with the use of muscle flaps. Various local flaps have been used in sternal wound reconstruction of which the pectoralis major muscle flap is considered a workhorse flap. The aim of this study was to develop a treatment algorithm for sternal wound infection. The

post sternotomy wound dehiscence will be divided into superficial and deep. Superficial wounds were treated with vinegar and deep wounds were treated with the pectoralis major muscle advancement flap. The treatment outcome was then studied.

Materials and methods

Clinical data

The patient cohort included in the study were 25 patients with sternal wound infections following sternotomy for cardiac surgeries, between the period of January 2016 and August 2021. The patients were then classified as superficial or deep wound infection. The ulcers with soft tissue cover over the sternal bone and steel wires were classified as super-

ficial wound infection. If the ulcer extended till the sternal bone and if sternal wires were visible, then ulcers were classified as deep sternal wound infection.

The superficial wound dehiscence was treated with 1% acetic acid dressing and deep wound infections were treated with the pectoralis muscle flap. Treatment outcomes were measured as favorable or unfavorable. Patients who healed without any complication irrespective of time were considered having a favorable outcome. In superficial wounds, an outcome was termed as unfavorable if the culture growth increased from scanty to heavy and discharge increased in a wound. In deep wound infection, gaping and wound re-dehiscence were considered as an unfavorable outcome. The demographic data of the patients and the time duration are described as a mean and a median. Average time duration taken for wound healing will be compared with the available study average and statistical significance tested with the ANOVA test.

Superficial wounds were treated with diluted edible vinegar dressing at two-day intervals till they healed completely. 4% acetic acid (edible vinegar) was diluted to 1% acetic acid with normal saline solution. Wound dressing was changed at two-day intervals. Baseline wound culture and sensitivity was done at the beginning of the treatment and repeated at 10 and 20 days. If an ulcer grew organisms, sensitivity-based antibiotics were administered to the patient. At 10 days, if there was no growth, then the antibiotics were stopped. Dressing was discontinued once the ulcer epithelialized completely.

Treatment method for deep sternal wound infections

Ulcers which were bone deep and those with exposed sternal wires were classified as deep sternal infections. In all these ulcers, after thorough debridement, bilateral pectoralis muscle ad-

vancement flaps were used to cover the wound. These ulcers were covered as early as possible to prevent the chances of sternal osteomyelitis and spreading mediastinitis. Flap surgery was deferred only in cases where wound cultures had heavy growth of organisms. In these circumstances, regular dressing and systemic antibiotics continued till the growth was scanty and then flap was performed.

Surgical technique

Patients were adequately prepared for surgery with optimization of blood pressure, blood sugar, hemoglobin level, albumin content and cardiopulmonary function. After appropriate anesthesia, thorough debridement was done and nonviable tissue was removed. Bilateral pectoralis major advancement flaps were planned. The flaps were elevated in the avascular plane deep to pectoralis major muscle and elevated from medial to lateral side. Both pectoralis muscles were advanced till the midline covering the sternum and the sternal hardware was reached. Both advanced ends were sutured to each other in the midline. The pectoralis fascia and the proximal rectus sheath were included in the closure. Deep dermis and skin sutures were closed in layers.

Outcome measures

Treatment outcomes were measured as favorable or unfavorable. Patients who healed without any complication irrespective of time were considered having a favorable outcome. In superficial wounds, an outcome was termed as unfavorable if the culture growth increased from scanty to heavy and discharge increased in the wound. In deep wound infection, gaping and wound re-dehiscence were considered as an unfavorable outcome.

Statistical analysis

The descriptive statistics is presented as a mean; the time taken for treatment

outcome is described as an average. The time duration taken to heal both superficial and deep sternal wound infection is compared with the population mean and the statistical significance is tested using the independent t-test.

Results

Between the period of January 2016 till August 2021, a total of 25 post sternotomy wound infection cases were included in the study. Fifteen patients had deep sternal wound infection and 10 patients had superficial wound infection. Out of the 15 patients with deep sternal wound infection, 5 were female and 10 were male patients, the youngest patient was 50 years and the oldest 82 years old. The mean of glycated hemoglobin (HbA1c) of the patients was 10.8. In 12 out of 15 patients, wounds healed within 2 weeks after flap surgery and the rest healed within 4 weeks after flap surgery (Tab. 1). None of them reported re-dehiscence. Out of the 10 patients with superficial wound dehiscence, 5 were females and 5 were males; the youngest patient was 43 years and the oldest 70 years old. Mean HbA1c of the patients was 7.96 years. An average time duration for healing of a superficial wound was 66.2 days (Tab. 2). None of them reported an increase in bacterial load or discharge from the wound during the course of the treatment. As compared to population mean of 51.2 days, superficial sternal wound infection in our study took significantly more time. (The T-value is 2.760143 and the P-value is 0.011053. The result is significant at $P < 0.05$). In deep sternal wound infection, wound healing took less time compared to a population mean of 90 days. (The T-value is -68.026425 and the P-value < 0.00001 . The result is significant at $P < 0.05$.)

Discussion

Median sternotomy approach is most commonly used for cardiac surgery because of its exposure and surgical con-

venience [3]. Surgical site infection is a known complication. As per the Centre for Disease Control (CDC) criteria, SSI is to be reported if infection occurs within 30 days after surgery or within 1 year if an implant was left in place. Various classifications of the surgical site infections are proposed. Pairolero and Arnold classified infected median sternotomies wounds into three types based on duration and clinical findings [5].

Type 1 infections occurred within the first week after surgery and presented with serosanguineous discharge only.

Type 2 infections occurred during the second to fourth week and presented with cellulitis and mediastinal suppuration.

Type 3 infections occurred many weeks to months after sternotomy and involved sinus tracts draining pus.

Another classification includes superficial and deep infections based on the involvement of the tissues. Superficial wound infections involve skin and soft tissue, whereas deep infections involve fascia and sternum [6]. Deep sternal infection represents more complex reconstructive problems. According to CDC, positive cultures from the mediastinal fluid, fever, sternal pain and instability, all these are considered as deep sternal wound infection (DSWI) [7,8]. However, in our study we classified only wounds which were bone deep with exposed bone and sternal wires as DSWI. Since positive wound cultures or fever can also be seen in post operative cases, these were not considered deep sternal wound infections for treatment.

The incidence of superficial sternal wound infections ranges from 0.5 to 8 % [9]. The diagnosis is usually made by the signs of erythema, drainage of pus or most commonly low-grade fever. Several techniques have been used for the management of superficial sternal wound infections. Surgical revision with open dressings or closed system has been proved to be effective. Martino A et al [10] presented their results

Tab.1. Demographic profile of deep sternal wound infection patients.

Subject No.	Age	Sex	HBA1c	Diagnosis	Duration (weeks)
1	60	F	7.1	CABG	2
2	58	F	8.4	CABG	2
3	65	F	9.4	CABG	2
4	68	M	11	CABG	3
5	58	M	9	CABG	2
6	64	M	10.8	CABG	2
7	50	M	7.4	TRSPLT	4
8	56	M	5.4	MVR	2
9	66	M	8.8	CABG	2
10	72	M	10	CABG	3
11	58	F	6.8	STOSM	2
12	63	M	10.6	CABG	3
13	62	F	9.4	CABG	2
14	56	M	8.9	CABG	2
15	82	M	9	CABG	2

CABG – coronary artery bypass graft, F – female, HBA1c – glycated haemoglobin – M – male, MVR – mitral valve replacement, STOSM – sternal osteomyelitis, TRSPLT – cardiac transplant

Tab. 2. Demographic profile of superficial wound infection.

Subject No.	Age	Sex	HbA1c	Surgery	Duration (days)
1	43	F	6	CABG	48
2	65	F	9	CABG	54
3	66	M	6.8	CABG	57
4	58	M	8.4	CABG	60
5	49	F	7.7	TRSPLT	78
6	70	M	9	CABG	80
7	55	F	6.4	TRSPLT	42
8	48	M	8.8	CABG	86
9	47	F	7.2	CABG	63
10	65	M	10.3	CABG	94

CABG – coronary artery bypass graft, F – female, HBA1c – glycated haemoglobin – M – male, TRSPLT – cardiac transplant

of negative pressure wound therapy in managing patients with superficial sternal wound infection in their article. They concluded that superficial wound infection was effectively controlled with the

negative pressure wound therapy dressing. A study done by Aygün et al showed a protective effect of locally applied rifamycin on sternal wound infections [11]. One more study indicated that if sternal

wound infection/dehiscence was limited and superficial, the wound could be treated daily with iodine-soaked gauze followed by surgical closure (when the wound was judged to be clean and dry) [10] were sufficient. Studies have been performed to assess the effectiveness of vinegar in treating infected wounds [12]. The efficacy of vinegar in treating sternal wounds has not been done in a systematic manner. It is known that acidification of a wound increases the pO_2 and reduces the histotoxicity of ammonia which may be present in bacterial infection (ammonia being less toxic in an acid environment) [13]. The majority of bacteria and fungi are alkaline in nature and acid media can definitely counter their infestation and thus bringing down the local wound infection. When used locally, edible vinegar (4% acetic acid), diluted to 1% with normal saline solution, can acidify the ulcer floor and promote granulation formation. It is also known to prevent bacterial growth / infestation and even some of fungal infection [14].

In our study, we used vinegar-based dressings for sternal wound optimiza-

tion. Edible vinegar dressing (4% acetic acid (edible vinegar) was diluted to 1% acetic acid with saline solution) was done at 2-day intervals. First gauze layer of the wound was soaked with the vinegar solution. Baseline wound culture and sensitivity was done at the beginning of the treatment and repeated at 10 and 20 days. In 10 of our cases all the wounds improved in terms of granulation as well as bacterial load. Although our cases took 4–8 weeks (Fig. 1A,B), all the wounds healed completely. We could not find any study using vinegar dressing for sternotomy wounds. In comparison to other modalities of dressing, vinegar dressing was efficient, low cost and readily available. However, a study which used conservative method for treatment, opined that it took 51 days in average [15] days to convert a sternal wound to a healthy wound. Later, one more procedure was used to cover the wound. In our study, only vinegar dressing was used and in some cases secondary suturing was done.

Deep sternal wound infections are more complex problems and their in-

cidence ranges from 0.7 to 2.3% [16]. It is important to distinguish DSWIs from superficial sternal wound infections because morbidity and mortality differed considerably among the two groups [17]. As per CDC, the diagnosis of deep sternal wound infection requires the presence of one of the following: (1) organism isolated from the culture of mediastinal tissue or fluid; (2) evidence of mediastinitis seen during surgery; or (3) presence of either sternal instability, chest pain, or fever ($> 38^\circ C$), and either purulent drainage from the mediastinum, isolation of an organism present in a blood culture, or culture of the mediastinal area [18].

However, in our study wound dehiscence which was bone deep with exposed sternal wires were only considered deep sternal wound infection (Fig. 2A) as the wounds with discharge only were conservatively treated with dressings only. As per CDC, DSWI patients require much more aggressive treatment involving early debridement, tissue cover and long-term antibiotics. We followed the same protocol and approached the patients with similar treatment. Patients suspected of DSWI were subjected to a CT scan of the chest, which assesses the depth of dehiscence and looked for retrosternal collection [19]. On clinical evidence of DSWI, empiric antibiotic therapy involving broad spectrum antibiotics was initiated. Antibiotics based on wound culture was initiated as soon as culture report was ready. Closure of the dehiscence was planned as soon as possible; flap was deferred only when the wound grew heavy growth of multi-resistant organism. Various techniques have been described for DSWI: omental transposition [20], unilateral or bilateral pectoralis major muscle turnover flap in mediastinitis [21], pectoralis major muscle transposition [22], bilateral myocutaneous pectoralis major muscle flaps [23], rectus abdominus muscle flap [24], latissimus dorsi muscle flap [25], microsurgical free flap [26], primary sternal closure

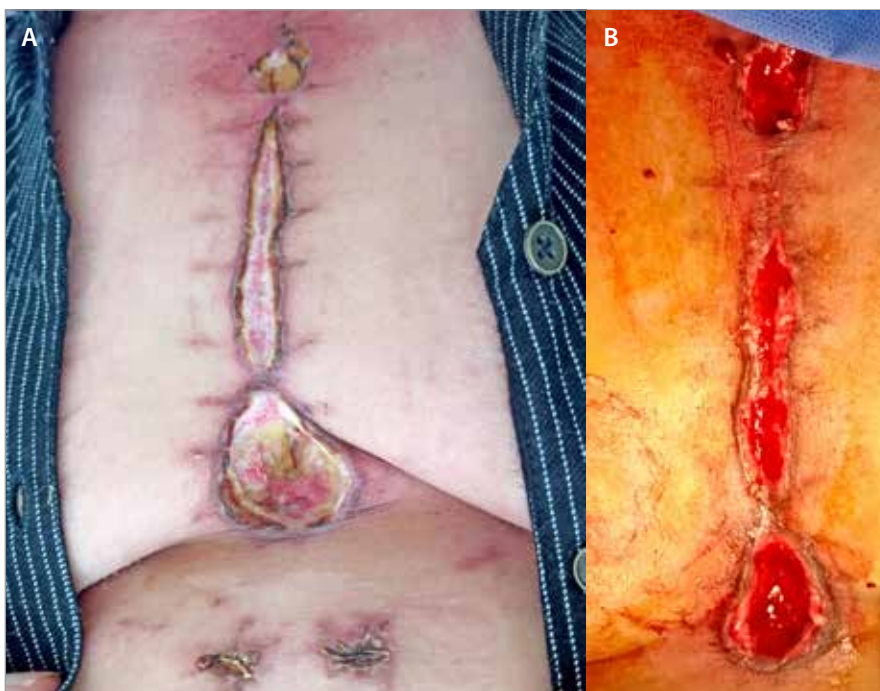


Fig. 1. A) Superficial wound infection – post-cardiac transplant; B) after 42 days of dressing.

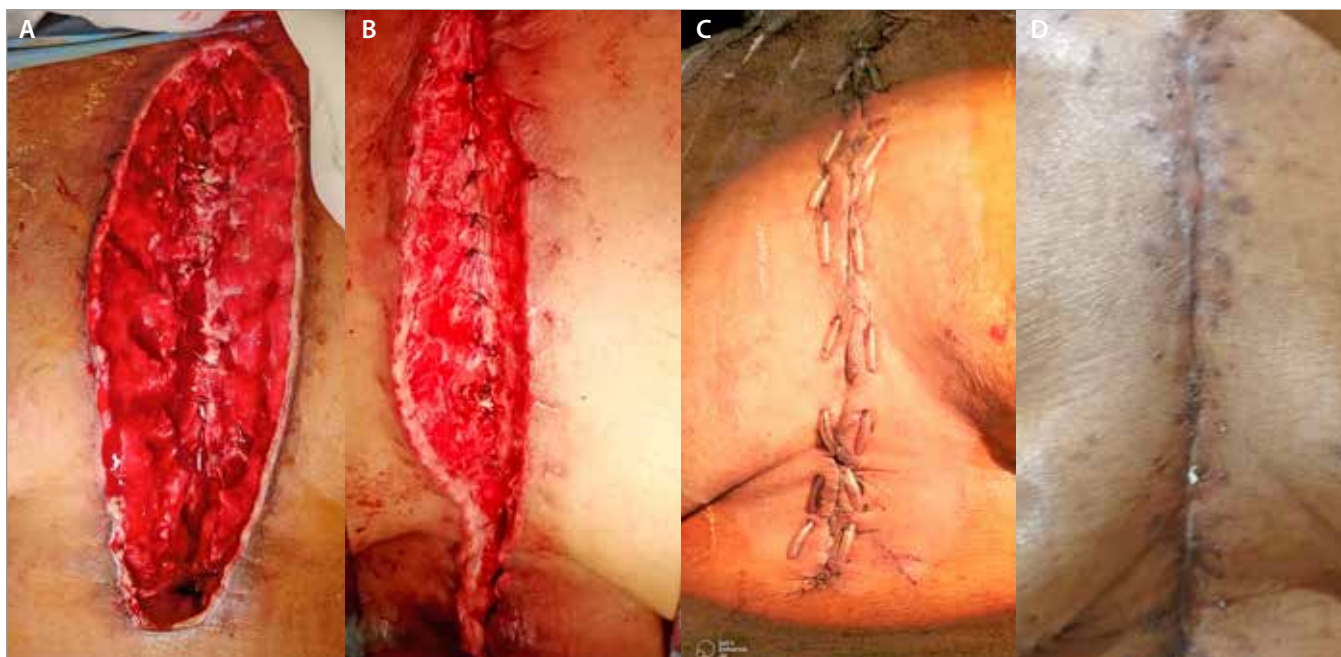


Fig. 2. A) Deep sternal wound infection – pre-operatively; B) after bilateral pectoral flap inset; C) day 10 after flap operation; D) day 20 after flap operation.

with titanium plate fixation [27], one-step radical sternal debridement and muscle flap reconstruction [28]. All these muscle flaps have an advantage. Muscle flaps increase the local blood flow, occlude the dead space. Muscles also deliver better antibiotic concentration and improve esthetic outcome [29]. Pectoralis major muscle has various advantages in post sternotomy cases. It is close to sternum and easy to detach without requiring additional incision, muscle has a rich blood supply and it is expendable. All these make it an ideal muscle for flap. Also, the bilateral pectoral muscle flap has shown better sternal stabilization than just rewiring the sternum [30]. The literature describes advantages and disadvantages of unilateral and bilateral pectoralis muscle flap. The main advantage of the unilateral pectoral muscle flap is that it preserves full strength in at least one arm but covers the sternum [3]. This needs at least one internal mammary artery to be intact. Spartalís et al [31] and Ortak et al [32] published a series of 55 patients and 48 patients, respectively, all had a successful outcome and not many functional deformi-

ties. At the same time, the advancement preserved both internal mammary arteries (IMA). In bilateral advancement of pectoralis major, the sternal origin is detached and it is reoriented to the midline where it is fixed to the opposite pectoralis muscle. This will not affect the function of the upper limb. Other studies conducted by Feng et al have reported the same. One of the disadvantages of bilateral pectoralis discussed in literature was that the muscle cannot cover the lower end of the sternum. In a study by Bongiolo junior et al, defects of the upper and middle thirds were covered with pectoralis major while the omentum and the rectus abdominis were used for lower third defects [33]. In our study, we did not use any additional method to cover the lower end of the sternum, only rectus fascia was utilized when required. We were successful in achieving tension free (Fig. 2B) repair and none of our cases had postoperative dehiscence. Davidson et al [34] also opined that the use of rectus abdominis was of no major advantage compared to bilateral pectoralis alone [35]. Some authors have proposed the refinements

in techniques of bilateral pectoralis advancement [36]. They have proposed preservation of IMA perforators by isolating them carefully instead of cutting them. This prevented the likely thrombosis of the IMA, preserving it for the use in future. One of the less aggressive therapeutic options includes a fasciocutaneous flap based on internal thoracic artery perforators [37]. However, in our study, debridement of wound followed by bilateral pectoralis major muscle advancement flaps proved to be effective (Fig. 2C,D) as all the patients recovered without any unfavorable outcome [38].

Conclusion

Median sternotomy is one of the most commonly used incision used for cardiac surgeries. As in any other surgeries, surgical site infection is a common phenomenon. Timely and appropriate intervention, depending on the depth of infection can reduce the morbidity as well as mortality. Simple edible vinegar (1% acetic acid) dressings are effective for the management of superficial sternal wound infections. In patients where wound infections were bone deep or in

cases where the sternal hardware was exposed, bilateral pectoralis major muscle advancement flaps reduced the morbidity of the patients. With this study, we could conclude that depth of the wound is a single most decision-making factor for muscle flap selection, irrespective of the bacterial culture. This proved to be an effective strategy for the management of superficial and deep sternal wound infections. Since the study had no comparison groups, the factors influencing the outcome are not completely evaluated. More patient studies are needed to ascertain this algorithm of treatment.

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