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Is steel wire closure of sternotomy better than polyester suture closure?

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Abstract

Introduction: Median sternotomy is the preferred approach for open heart surgeries. The sternotomy incision is predominantly closed with either steel wire or polyester suture. The type of material used is primarily based on the surgeon's choice, and both materials achieve a good result. No prospective clinical study has been undertaken to evaluate differences in the incidence of wound infection and the degree of pain associated with both techniques.

Patients and methods: Our randomized controlled double-blind study included 200 adults undergoing single-valve replacement. The technique of surgery, apart from the material used for sternal closure, was the same in both groups. Postoperatively, patients were analyzed for wound infection and wound pain based on the ASEPSIS score and Numeric Pain Rating Score, respectively.

Results: The polyester suture group had a significantly higher mean ASEPSIS score, indicating a higher incidence of wound infection, and more late wound complications. The polyester suture group also had a significantly higher mean pain score. The steel wire group had significantly higher mediastinal drain output in the first 48 h after surgery.

Conclusion: The use of polyester suture for sternal closure in adult patients results in increased wound infection, wound pain, and late wound complications, but lower mediastinal drain output.

Keywords

Steel wires, Pain measurement, Surgical wound infection, Suture techniques, Sutures, Sternum

Introduction

The median sternotomy, first popularized by Julian and colleagues[1] in 1957, has become the incision of choice for cardiac surgeons because it provides excellent mediastinal exposure, is relatively pain-free, and heals well.[2,3] However, there is a 0.5% to 2.5% risk of sternal separation or dehiscence.[4] This complication causes not only high mortality but also prolonged morbidity.[5] Sternal wound infection is an important precursor of sternal dehiscence. Although there are many factors known to increase the risk of sternal wound infection (age, female sex, duration of hospitalization prior to surgery, reexploration, reoperation, duration of the surgical procedure, duration of cardiopulmonary bypass, amount of blood transfusion, duration of mechanical ventilation, and intensive care unit stay),[6] some studies have implicated polyester suture as a risk factor for sternal wound infection.[7] The aim of our clinical study was to compare the 2 conventional techniques of sternal closure (steel wire and polyester suture) in terms of early sternal infection, sternal dehiscence, mediastinal tube drainage, and wound pain in patients undergoing elective single-valve replacement surgery via a median sternotomy.

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Patients and methods

This randomized controlled double-blind study involved 200 adults, aged 18 to 45 years, undergoing elective single heart valve replacement surgery. The study was approved by our institutional ethics review board, and informed written consent was obtained from all patients. Patients with preexisting renal dysfunction (serum creatinine $> 1.5\,mg \cdot dL^{-1}$) or hepatic dysfunction (serum bilirubin $> 2\,mg \cdot dL^{-1}$), redo cardiac surgery, and those requiring double-valve replacement were excluded from the study. Patients with chronic illnesses such as tuberculosis, chronic obstructive pulmonary disease, diabetes mellitus, asthma, and connective tissue disorders or muscle dystrophy were also excluded.

All patients were admitted 1 day prior to surgery. All 200 patients received intravenous (IV) cefoperazone 1 g and sulbactam 500 mg as prophylactic antibiotics at the time of induction of anesthesia, and the same antibiotics were continued twice daily postoperatively for two days. The patients included in the study were operated on by the same surgical team. Prior to draping, the skin was painted with 10% povidone iodine solution, allowed to dry for five minutes, and covered with polyurethane drapes. Valve replacement was performed through a standard median sternotomy. Bone wax and diathermy were used sparingly for hemostasis. Two 36 F chest tube drains were placed at the end of the procedure, one in the pericardial cavity and the other retrosternally. Suction was not applied to the mediastinal drains. The sternum was closed using either no. 5 steel wire (Truesteel, Suture India Pvt. Ltd., Bangalore, India) or no. 5 polyester suture (Johnson & Johnson Ltd., Mumbai India) on a tapercut needle. In both groups, the closure was performed in a figure-of-8 manner using four sutures, as shown in Figure 1. The first suture or wire was inserted through the manubrium 1.5 cm lateral to midline. The second suture or wire was inserted first through the manubrium and then peristernally in the sternum. The other two sutures or wires were inserted peristernally. The two free ends of the sutures or wires were pulled and crossed in a figure-of-8 configuration. For steel wire, using a rotary movement of the wrist along with a vertical pull on the wires, the wires were twisted tightly until the two bone edges were approximated. Similarly, polyester sutures were tightened in a figure-of-8 manner to approximate the two edges of the sternum. After sternal closure, the wounds were irrigated with saline and 10% povidone iodine. Subcutaneous tissues were closed in two layers using 1/0 polyglactin suture (Suture India Pvt. Ltd., Bangalore, India), and the skin edges were approximated subcuticularly with 3/0 polyglactin suture (Suture India Pvt. Ltd., Bangalore, India). In the intensive care unit, patients were extubated when they were awake, hemodynamically stable, their arterial blood gases met the criteria for extubation, and there was no significant bleeding from the chest drains. Patients were discharged from the intensive care unit when they were off inotropes and the chest drains had been removed. According to our protocol, all patients were discharged from the hospital on postoperative day 10.

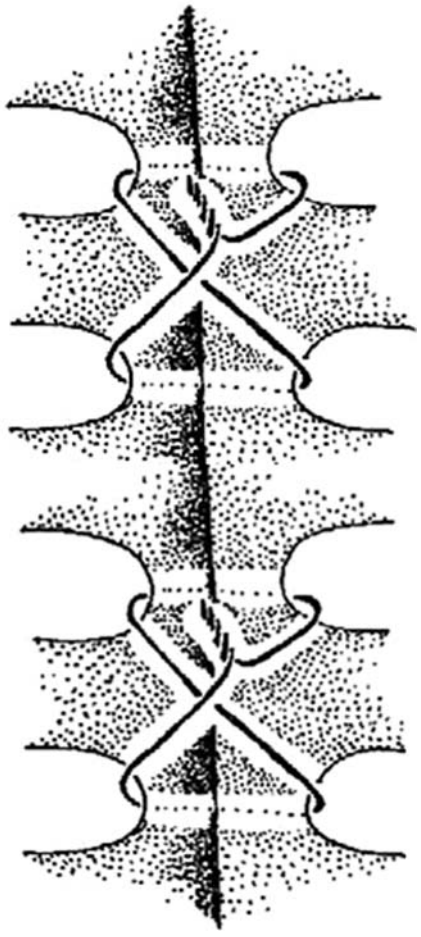

Figure 1. Diagram showing our technique of sternal closure with steel wire suture in a figure-of-8 formation. Polyester suture was inserted by a similar method, and tied.

From postoperative day 1 to 10, the patients were assessed for surgical site pain at least thrice daily (before administering analgesics) and at any other time when a patient complained of pain. The pain score was calculated based on the 0–10 Numeric Pain Rating Scale (Table 1).[8] Pain was graded as mild, moderate, or severe. After pain assessment, patients received IV tramadol 50 mg thrice daily for the first 48 hours after surgery, then tramadol 50 mg orally thrice daily for another three days. For analysis, the highest daily pain score for each patient was considered. Patients who had severe pain despite tramadol were further supplemented with intravenous or oral diclofenac.

In all patients, the dressing was changed for the first time on postoperative day three, and then once daily thereafter until postoperative day 10. The wound was inspected for erythema, serous or purulent discharge, separation of superficial or deep tissues, and sternal mobility, and scored by the ASEPSIS wound scoring system for surgical site infection (Table 2).[9] For analysis, we divided the patients into three groups: ASEPSIS score < 20, no wound infection; ASEPSIS score 20–40, mild to moderate wound infection; and ASEPSIS score > 40, severe wound infection (Table 2). Prophylactic IV antibiotics were continued until postoperative day two. No further antibiotics, either oral or IV, were administered if there were no obvious signs of bacteremia. Patients who had a good postoperative recovery, no discharge from the sternal wound, and a stable sternum were discharged from the hospital on postoperative day 10. Patients who had either a wound discharge, wound infection or sternal dehiscence were discharged only after complete recovery. In patients who had a discharge from the sternal wound, the discharge was sent for bacterial culture and sensitivity. Frequency of wound dressing depended on the amount of soakage, and IV or oral antibiotics were given as per the culture sensitivity. The sternum was assessed daily for stability. A diagnosis of sternal dehiscence was made on clinical findings of sternal click or evidence of sternal instability during coughing or respiration. In patients who had a purulent discharge from their wound, the skin and subcutaneous tissues were opened to drain the pus, and the wound was debrided thoroughly under anesthesia. The length of wound opening and the type of anesthesia were decided by the extent of wound involvement and the sternal in stability. Patients who had evidence of sternal dehiscence were promptly operated on for wound debridement and sternal refixation under general anesthesia, and all of these patients received antibiotics until there was no discharge from the sternal wound. Patients were

Table 1. Grading of pain based on the Numeric Pain Rating Scale (8).

Rating	Pain level
0	No pain
1–3	Mild pain (nagging, annoying, interfering little with ADL)
4–6	Moderate pain (interfering significantly with ADL)
7–10	Severe pain (disabling, unable to perform ADL)

ADL: activities of daily living.

Table 2. The ASEPSIS wound scoring system (9).

Proportion of wounds affected						
Wound characteristics	0	< 20	20–39	40–59	60–79	> 80
Serous exudates	0	1	2	3	4	5
Erythema	0	1	2	3	4	5
Purulent exudates	0	2	4	6	8	10
Separation of deep tissues	0	2	4	6	8	10
Characteristic		Contribution to the ASEPSIS score				
Daily scores						
Serous exudates		0–5 by extent for 1 week				
Erythema		0–5 by extent for 1 week				
Purulent exudates		0–10 by extent for 1 week				
Separation of tissues		0–10 by extent for 1 week				
Score within 2 months						
Antibiotics		10				
Drainage under local anesthetic		5				
Debridement under general anesthetic		10				
Bacterial isolation		10				
Stay prolonged> 14 days		5				
Development of pus as an outpatient		5				
District nurse visit to dress wound		5				

Given score only on 5 of 7 days. Highest weekly score used. Category of infection: total score 0–10: satisfactory healing; 11–20: disturbance of healing; 20–30: minor wound infection; 31–40: moderate wound infection; >40: severe wound infection.

discharged from the hospital once the wound had healed and the sternum had stabilized.

The polyester suture group and the steel wire group included 100 patients each. Both groups were comparable in terms of age, weight, aortic crossclamp time, cardiopulmonary bypass time, and inotropic score, as shown in Table 3.[10] Patients were followed up one week after discharge and at one, three, and six months postoperatively in the outpatient department. During follow-up, the sternal wound was inspected for wound healing and sternal stability.

Table 3. Characteristics of 200 patients undergoing sternal closure with polyester suture or steal wire.

Variable	Polyester suture ($n = 100$)	Steel wire ($n = 100$)	p value
Age (years)	32.8 ± 11.2	31.5 ± 9.2	0.3709
Males	54%	46%	0.3222
Weight (kgs)	62.5 ± 7.8	61.2 ± 8.1	0.2490
Mitral valve replacement (n)	63	70	0.3687
Aortic valve replacement (n)	37	30	0.3687
Cardiopulmonary bypass time (mins)	93 ± 11.3	90 ± 10.5	0.0532
Blood transfusion (units)	2.1 ± 0.8	2.3 ± 0.9	0.0983
Inotropic score	12.2 ± 3.4	11.5 ± 3.1	0.1298
Duration of ventilation (ho)	12.5 ± 5.9	13.9 ± 5.6	0.0868
Intensive care unit stay (days)	3.2 ± 1.5	2.9 ± 1.3	0.1323
Hospital stay (days)	12.2 ± 7.8	14.1 ± 7.4	0.0787

Results

In the polyester suture group, 94 patients had satisfactory healing or mild wound infection, four had moderate wound infection, and two had severe wound infection and one patient had sternal dehiscence requiring debridement and refixation under general anesthesia. In the steel wire group, four patients had moderate wound infection but none had severe wound infection or sternal dehiscence. In both groups, the mean ASEPSIS score increased from day three to day five and then decreased gradually (Figure 2). Mean ASEPSIS score was less than 10 in both groups (Table 4), suggestive of satisfactory wound healing; however, it was significantly higher in the polyester suture group. When we compared the patients with mild, moderate, and severe sternal wound infection, based on the ASEPSIS score (Table 5), the numbers of patients in each of the three groups were comparable. Analysis of patients with mild wound infection (mean ASEPSIS score < 20) revealed a significantly higher ASEPSIS score in polyester suture group (9.09 ± 2.94) compared to the steel wire group (5.98 ± 2.7; $p < 0.0001$). Analysis of patients with moderate and severe sternal wound infection showed that the difference in mean ASEPSIS score was not statistically significant between the two groups (Table 5). In the polyester suture group, 56 patients had moderate wound pain and 36 patients had severe wound pain. In the steel wire group, 62 patients had moderate wound

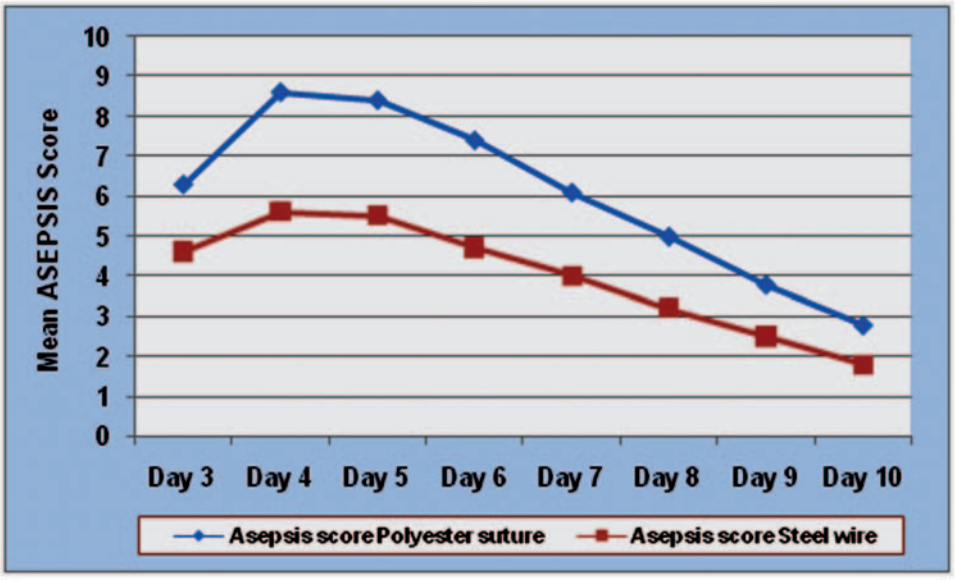

Figure 2. Mean ASEPSIS scores in the polyester suture and steel wire groups.

pain and 32 had severe wound pain. The difference between the groups was not statistically significant ($p = 0.06$). In both the groups, wound pain increased up to postoperative day three and then gradually decreased (Figure 3). Although the mean pain score was $\leqslant 4.5$ in both groups, it was significantly higher in the polyester suture group during most of the first 10 days postoperatively (Table 4). Also, the mean pain score in patients with severe pain (pain score 7–10) was significantly higher in the polyester suture group (8.11 ± 1.49) compared to the steel wire group (7.0 ± 1.36; $p = 0.03$; Table 5). Mean mediastinal drain output at 24 hours and 48 hours after surgery was significantly less in the polyester suture group (Table 4).

Table 4. Postoperative data in 200 patients undergoing sternal closure with polyester suture or steal wire.

Variable	Polyester suture ($n = 100$)	Steel wire ($n = 100$)	p value
ASEPSIS score			
Day 3	6.3 ± 3.4	4.6 ± 2.9	0.0002
Day 4	8.6 ± 5.8	5.6 ± 5.0	0.0001
Day 5	8.4 ± 6.0	5.5 ± 5.2	0.0003
Day 6	7.4 ± 6.8	4.7 ± 4.6	0.0012
Day 7	6.1 ± 6.1	4.0 ± 3.5	0.0032
Day 8	5.0 ± 6.4	3.2 ± 3.4	0.0138
Day 9	3.8 ± 4.5	2.5 ± 2.6	0.0132
Day 10	2.8 ± 2.9	1.8 ± 2.2	0.0066
Pain score			
Day 1	4.0 ± 1.2	3.5 ± 0.7	0.0004
Day 2	4.5 ± 1.5	3.8 ± 1.0	0.0001
Day 3	4.5 ± 2.2	4.3 ± 1.4	0.4440
Day 4	4.4 ± 2.2	4.2 ± 1.6	0.4631
Day 5	4.4 ± 2.4	3.8 ± 1.7	0.0427
Day 6	4.1 ± 2.5	3.2 ± 1.6	0.0028
Day 7	3.5 ± 2.2	2.6 ± 1.3	0.0005
Day 8	3.1 ± 2.0	2.0 ± 1.1	<0.0001
Day 9	2.5 ± 1.7	1.5 ± 1.0	<0.0001
Day 10	2.1 ± 1.5	1.0 ± 0.8	<0.0001
24-hr drainage (ml)	214.1 ± 44.2	254.8 ± 37.1	<0.0001
48-hr drainage (ml)	330.5 ± 35.8	374.1 ± 38.0	<0.0001

During follow-up of six months, five patients in the polyester suture group required removal of a total of eight sutures (two sutures each in three patients, and one suture each in two patients) because of suture granuloma formation (three patients) or sinus formation (two patients). Only two patients required removal of three steel wires (two wires in one patient, and one wire in the other) for sinus formation in the first, and for persistent pain in the second. There was no incidence of suture granuloma formation in the steel wire group. Nine patients in the polyester suture group had increased sternal mobility, and three in the steel wire group had similar findings. None of the patients in either group had delayed wound infection or sternal dehiscence during six months of follow-up.

Discussion

Both suture materials led to satisfactory wound healing, as shown by a mean ASEPSIS score < 10 in both groups. Although the polyester suture group had a higher incidence of serous wound discharge and mild wound infection, the incidence of moderate and severe wound infection was comparable in both groups. The higher incidence of wound infection and discharge with polyester suture is due probably to the fact that it is braided in nature.[11] Therefore, polyester suture may

Table 5. Comparison of ASEPSIS and pain scores after sternal closure with polyester suture or steel wire.

Variable	Polyester suture ($n = 100$)			Steel wire ($n = 100$)			p value
ASEPSIS score	< 20	$20 < 40$	$\geqslant 40$	< 20	$20 < 40$	$\geqslant 40$	
No. of patients	94	4	2	96	4	0	0.100[a]
Mean score	9.09 ± 2.94	28.50 ± 7.77	44.0	5.98 ± 2.7	30.50 ± 3.53	–	0.0001[b] 0.6558[c]
Pain score	< 4	$4 < 6$	$\geqslant 6$	< 4	$4 < 6$	$\geqslant 6$	
No. of patients	8	56	36	6	62	32	0.0641[d]
Mean score	3.00 ± 0.00	4.46 ± 0.5	8.11 ± 1.49	3.00 ± 0.00	4.52 ± 0.5	7.00 ± 1.36	0.5164[e] 0.0022[f]

[a]Frequency of suture vs. wire by chi-square test.
[b]Score < 20 for suture vs. wire by t test.
[c]Score $20 < 40$ for suture vs. wire by t test.
[d]Frequency of suture vs. wire by chi-square test.
[e]Score $4 < 6$ for suture vs. wire by t test.
[f]Score $\geqslant 6$ for suture vs. wire by t test.

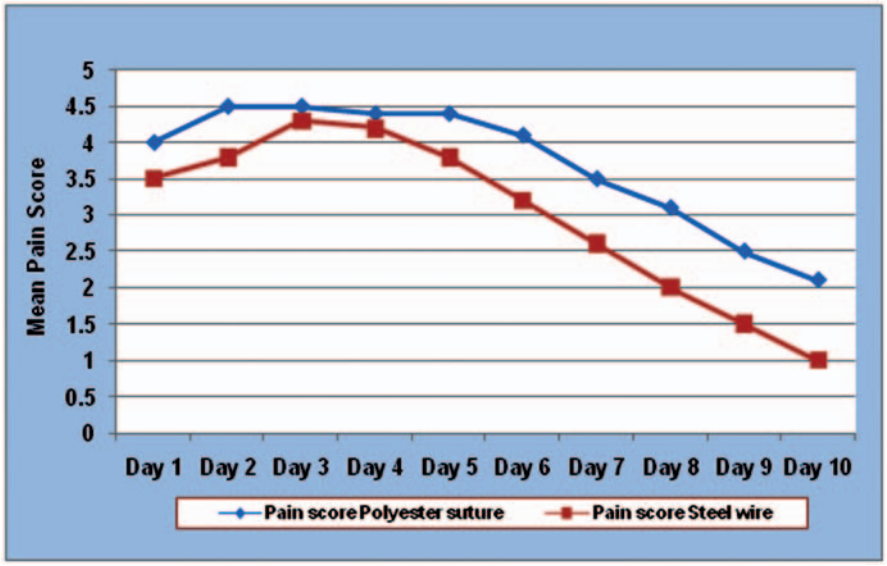

Figure 3. Mean pain scores in the polyester suture and steel wire groups.

incite a greater inflammatory reaction.[12] Furthermore, sternal fixation with polyester suture is 10-times less rigid than steel wire,[7] which permits a greater mobility of the sternal edges and keeps the overlying skin and subcutaneous tissues under more stress.

Our findings of comparable incidences of moderate and severe wound infection in both groups are contrary to the findings of Shuhaiber and colleagues[13] and Vanscheidt and colleagues[14] who found higher incidences of bacterial adherence and wound infection with polyester suture. They suggested that this was because of the braided nature of polyester suture. We suggest that the braided nature of this material does not increase the risk of early postoperative severe wound infection and sternal dehiscence, but it increases the risk of chronic complications such as stitch granuloma and sternal sinus, as seen in our series. The late postoperative increase in the incidence of sternal mobility with polyester suture is because of gradual cutting through of the sternum by the suture.[7,13,14] Due to this, 9% of the patients with polyester suture developed sternal instability during 6 months of follow-up, compared to 3% of patients with steel wires.

Both groups had comparable numbers of patients with mild, moderate, and severe wound pain, and the mean pain scores in patients with mild and moderate wound pain were also comparable. However, in patients with severe wound pain, the polyester suture group had a significantly higher mean pain score compared to the steel wire group. This is because of less rigid sternal fixation with polyester suture, which allows greater movement of the sternal edges, as suggested by Casha and colleagues.[7]

We are unclear about the etiology of the increased mediastinal bleeding with steel wire compared to polyester suture. We presume that polyester suture, being polyfilament in nature, exposes a larger surface area to activate the blood coagulation cascade and clog the suture holes, while steel wire, being monofilament and inert in nature, is unable to activate the coagulation cascade. The other reason may be that polyester suture, being braided, imbibes the fluid and clogs the needle holes.

The main limitation of our study was the small number of patients. Therefore, we suggest a larger randomized controlled trial to confirm our findings. We concluded that steel wire is superior to polyester suture for sternal closure in adult patients. Use of steel wire is associated with a lower incidence of wound discharge, sternal dehiscence, severity of wound pain, and late complications such as suture granuloma and sternal sinus.

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Conflicts of interest statement

None declared.

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