JOURNAL OF PLASTIC SURGERY AND HAND SURGERY
2021, VOL. 55, NO. 3, 162–166
https://doi.org/10.1080/2000656X.2020.1856672

ARTICLE

Muscle flaps for sternoclavicular joint septic arthritis

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ABSTRACT

Septic arthritis of the sternoclavicular joint (SC) is rare. The most accepted technique for reconstruction of the defect after SC joint resection is the use of muscle flaps. We hypothesized that resection of ribs with the SC joint impacts timing, type and outcomes of reconstruction. This is a retrospective review of 44 patients who underwent wound closure with muscle flap following resection of the SC joint for septic arthritis over 14 years period from a single institution. Patients were divided into two groups based on the resection of the adjacent ribs with the SC joint. We found 18 (40.9%) patients with SC joint resection only and 26 (59.1%) with concomitant resection of the adjacent ribs. Patients in the rib resection group were younger, did not need SC joint fluid aspiration, and had higher tissue culture positivity ($p < .05$). Rib resection with the SC joint was found to be associated with delayed reconstruction (57.7% vs 22.2%, $p = .030$), need for serial debridement's (2 vs 1, $p = .009$), increased days from debridement to reconstruction for a subset of patients (75% percentile of 8 days vs. 0 days, $p = .024$), and longer hospital stay (18 vs 9, $p = .006$). Flap complications were higher in rib resection group (26.9% vs 5.6%, $p = .67$). Reconstruction following resection of the SC joint for septic arthritis is guided by the surgeon's impression regarding source control of infection. Rib resection concomitantly with joint resection appears to be a useful indicator of disease extent and may help guide clinical decision making in this challenging scenario.

ARTICLE HISTORY
Received 21 June 2020
Revised 30 October 2020
Accepted 23 November 2020

KEYWORDS
Flaps; latissimus dorsi flap; repair; infection; plastic surgery

Introduction

Septic arthritis of the SC joint is rare [1]. Primary SC joint osteomyelitis is different from sternal wound infections, which result from sternal wound dehiscence with mediastinitis, and is also different from sternomanubrial joint infections [2,3]. The disease is believed to arise from a distant source, disseminate hematogenously, and then seed the sternoclavicular joint [1]. Some of the known risks factors include; diabetes mellitus, Intravenous Drug Use (IVDU) and poor dental hygiene [2]. Pain and swelling directly overlying the joint in the most common presentation. Diagnosis is based on imaging; most commonly computed tomography. Management options range from incision and drainage of the joint to resection. The most accepted technique described for reconstruction of the defect resulting from SC joint resection is use of muscle flaps [4–9].

There is paucity of literature with regards to reconstruction of these wounds after resection of the SC joint. Reconstruction of the wounds can be performed immediately after the resection of the SC joint or the wound can be closed temporarily using negative pressure wound therapy to undertake reconstruction at a later time [2]. Joethy et al. proposed a wound classification system for SC joint defect resulting after resection for septic arthritis. However, they had small sample size and did not have group comparisons. In our experience, the resection of ribs concomitantly with resection of the SC joint can guide reconstruction. We hypothesized that concomitant resection of the ribs with the SC joint impacts timing, type and outcomes of reconstruction.

Methods

This is a retrospective review of 44 patients who underwent wound closure with muscle flap following resection of the sternoclavicular joint for septic arthritis over 14 years period from a single institution by multiple plastic surgeons within the division of Plastic and Reconstructive surgery. We only included cases of primary SC joint osteomyelitis. Patients were divided into two group based on the resection of the adjacent ribs with the SC joint. Reconstruction was performed using pectoralis major muscle in 42 cases and latissimus dorsi in 2 cases. There were no distant free tissue transfers.

Surgical resection

Diagnoses of SC joint infections were made by the cardiothoracic surgery team, and patients were admitted to the hospital for intravenous antibiotics. Surgical resection of the SC joint was performed. If concomitant rib involvement was found, then resection of the ribs was also undertaken.

Reconstruction

Immediately following resection, plastic surgery consultation was done. Factors that were taken into consideration included; physiologic status of the patient to undergo further operation, and pedicle availability depending on resection type. Thoracoacromial pedicle was the first choice if usable, and could be ipsilateral,

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contralateral, or bilateral. If thoracoacromial pedicle was sacrificed, or the pectoralis major muscle was not available from previous operations then thoracodorsal was the next pedicle of choice, always unilateral in our series. In the rare occasion that both thoracoacromial and thoracodorsal flaps are not sacrificed then we recommend evaluating internal mammary pedicle for use, although we did not utilize this flap in our series.

An Institutional Review Board approval was obtained for this study. We extracted data on patient demographics, comorbidities, microbiology, operative characteristics, and postoperative complications from chart reviews. Descriptive statistics were used for group comparisons using Chi-squared test and Fisher exact test for categorical data. For continuous variables depending on normality of distribution student t test and equivalent non-parametric tests were done. Given the small sample size logistic regression analysis could not be performed to identify independent risk factors. All the statistical analysis were performed using JMP 9.0.0 software (SAS institute Inc., 2010, Cary NS, USA).

Results

We found 18 (40.9%) patients who had undergone SC joint resection only and 26 (59.1%) who had resection of the adjacent ribs with the SC joint. Patients in the rib resection group were younger, did not need SC joint fluid aspiration, and had higher tissue culture positivity ($p < .05$). Males were predominant in each group, at 72.2% and 76.9%. Obesity, defined as body mass index of greater than 30 kg/m^2, was more common in rib resection group patients (38.5%). Fever and leukocytosis were about the same in each group of patients at presentation. Diabetes mellitus was the most common comorbidity in both groups (44.4% and 57.7%), followed by smoking (50% and 46.2%). All of the patients were diagnosed based on CT scan where abscess, air, and osteonecrosis were common findings. A majority of these patients had bacteremia, 50% and 76.9% in each group respectively, with a minority having endocarditis. Joint fluid aspirate was done in equivocal cases only, where diagnosis was not confirmed based on imaging alone. Methicillin Sensitive Staphylococcus Aureus was the most common organism, as shown in Table 1. All patients completed 6 weeks of intravenous antibiotics based on the final culture and sensitivity results

Table 2 shows the operative characteristics. A minority of patients in each group had phlegmon at initial debridement. More patients needing reconstruction following concomitant rib resection required post-operative blood transfusions. Concomitant involvement of ribs, was found to be a significant predictor of delayed reconstruction (57.7% vs. 22.2, $p = .030$), more need for serial debridement's (2 vs 1, $p = .009$), increased days from debridement to reconstruction for a subset of patients (75% percentile of 8 days vs. 0 days, $p = .024$), and longer hospital stay (18 vs. 9, $p = .006$). Flap complications were higher in rib resection group, 26.9% versus 5.6% in no rib resection group ($p = .67$). All wounds healed without any patients experiencing total flap loss. This included seroma, hematoma, lung herniation, and retained drain. All patients reported good shoulder function at average follow up of 31 months (Table 3).

Table 1. Patient demographics, comorbidities and microbiology.

Variables	No rib resection $n = 18$ (40.9%)	Rib resection $n = 26$ (59.1%)	p Value
Age, mean ± SD	54 ± 12	46 ± 12	**.045**
Gender			.74
Male	13 (72.2%)	20 (76.9%)	
Female	5 (27.8%)	6 (23.1%)	
Obesity, BMI >30	4 (22.2%)	10 (38.5%)	.33
Fever	8 (44.4%)	11 (42.3%)	1.00
Leukocytosis	7 (38.9%)	11 (42.3%)	1.00
Diabetes mellitus	8 (44.4%)	15 (57.7%)	.54
Coronary artery disease	2 (11.1%)	2 (7.7%)	1.00
Hypertension	8 (44.4%)	11 (42.3%)	1.00
Intravenous drug use	4 (22.2%)	10 (38.5%)	.33
Smoking	9 (50%)	12 (46.2%)	1.00
Cirrhosis	4 (22.2%)	6 (23.1%)	1.00
Hepatitis C	4 (23.5%)[a]	7 (26.9%)	1.00
Other hepatitis	1 (5.8%)	0 (0%)	.40
CT scan	18 (100%)	26 (100%)	1.00
Abscess	11 (61.1%)	23 (88.5%)	.06
Air	4 (22.2%)	9 (34.6%)	.51
Osteonecrosis	13 (72.2%)	18 (69.2%)	1.00
Bacteremia	9 (50%)	20 (76.9%)	.54
Endocarditis	3 (16.7%)	0 (0%)	.06
Joint fluid aspirate	4 (22.2%)	0 (0%)	**.023**
Blood cultures	9 (50%)	11 (42.3%)	.76
Tissue cultures	8 (44.5%)	21 (80.1%)	**.023**
MSSA	10 (55.6%)	12 (46.2%)	.76
MRSA	1 (5.6%)	3 (11.5%)	.63
Strep	1 (5.6%)	4 (15.4%)	.63
Pseudomonas	0 (0%)	2 (7.7%)	.51
E coli	0 (0%)	1 (3.9%)	1.00
Candida	0 (0%)	1 (3.9%)	1.00

SD: Standard Deviation; BMI: Body Mass Index.
p Value for Age reflects t-test; all others reflect Fisher's Exact test.
[a]Missing data for one patient.

Discussion

Aggressive resection of the SC joint, any adjacent ribs and associated soft tissues for septic arthritis can result in a large wound in the upper chest and base of the neck with exposed critical structures in the superior mediastinum. Most of the literature pertaining to the reconstructive of these wounds is limited to case report and short case series [4–8]. Our group has previously demonstrated that reconstruction of these wounds using muscle flaps are associated with improved outcomes [2]. We are presenting our extensive experience with the largest reported case series describing reconstruction of the SC defects resulting from septic arthritis. We describe that the reconstructive surgeons can use the involvement and resection of the adjacent ribs as an indicator of timing and type of reconstruction. This should help not only the surgeons in their decisions regarding reconstruction but also to inform patients about the likely increased risk of complications.

Following resection of the SC joint there is a large soft tissue defect that needs to be filled with vascularized tissue to ensure successful treatment. It is not for the closure of the skin that we recommend muscle flaps. Muscle flaps have been studied to be better antibiotic delivery system into the wound by the virtue of being vascularized [9]. Our study highlights the importance of the extent for SC joint infection and evaluates its utility in reconstructive surgical planning. The patients in rib resection group were younger, obese, IV drug users, presented with abscesses, had bacteremia, positive tissue cultures and did not need joint fluid aspiration Joint fluid aspiration is reserved for equivocal cases. Given the fact that none of the patients in rib resection group underwent joint fluid aspiration suggests that this patient group had advanced disease at presentation without any doubts about the diagnosis of SC joint osteomyelitis. Operatively, the fact that these patients could not undergo immediate reconstruction and needed serial debridement's before they were ready for definitive closure also points towards extent of the disease. Although intraoperative transfusion did not reach statistical significance but there was trend towards increased transfusion requirements in the rib

Table 2. Operative characteristics and disposition.

Variables	No rib resection $n = 18$	Rib resection $n = 26$	p Value
Phlegmon, *n*	9 (50%)	10 (38.5%)	.54
Transfusion, *n*	0 (0%)	4 (15.4%)	.13
Days from admission to OR, median (IQR)	0 (0, 0)	0 (0, 0)	.72
Total number of surgeries, median (IQR)	1 (1, 1)	2 (1, 3)	**.009**
Days from initial operation to reconstruction, median (IQR)	0 (0, 0)	0 (0, 8)	**.024**
Reconstruction			**.030**
Immediate	14 (77.8%)	11 (42.3%)	
Delayed	4 (22.2%)	15 (57.7%)	
ICU days, median (IQR)	0 (0, 1)	0 (0, 0)	.67
Flap-related complications	1 (5.6%)	7 (26.9%)	.11
POD from surgery to discharge, days, median (IQR)	9 (4, 17)	18 (11, 28)	**.006**
Disposition			.96
Home	11 (61.1%)	14 (53.8%)	
Skilled Nursing facility	4 (22.2%)	7 (26.9%)	
Inpatient rehabilitation	2 (11.1%)	4 (15.4%)	
Other	1 (5.6%)	1 (3.8%)	

OR: Operating Room; ICU: Intensive Care Unit; POD: Post-operative day; IQR: Interquartile range.

Table 3. Complications and follow up.

Variables	Type 1 No rib resection $n = 18$ (%)	Rib resection 2 wound $n = 26$
Seroma	1 (5.6%)	0 (0%)
Hematoma	0 (0%)	4 (15.4%)
Lung herniation	0 (0%)	1 (3.8%)
Retained drain	0 (0%)	1 (3.8%)
Skin flap necrosis	0 (0%)	1 (3.8%)
Follow up, mean (weeks)	42.56	24.12

resection group. This translated into increased complications rates in the rib resection group. Please note that all of these complications were flap related.

The reconstruction of SC wounds depends on the vascular pedicle [2,4]. The first choice is use of pectoralis major muscle, either as rotation advancement flap based on thoracoacromial pedicle or as turn over flap based on internal mammary artery, IMA perforators. Pectoralis major muscle is a type V flap which derives its blood supply from thoracoacromial artery, the lateral thoracic artery, the IMAs and, to a lesser extent, the superior thyroid artery [10]. Given the centrality of the wound flaps from either side can be used. When using pectoralis as rotation advancement flap from contralateral side, either because of unavailability of the ipsilateral pectoralis major due to thoracoacromial pedicle sacrifice, or the need for bilateral flaps, we recommend releasing the medial humeral head tendon which aids in rotation and advancement. Although pectoralis major muscle turn over flap has been described for sternal wounds, we do not recommend it given the unreliability of the internal mammary artery pedicle from the debridement required to clear the infection.

Important anatomical considerations at the time of resection and debridement of the SC joint are knowledge of the vascular pedicle and its innervation. The vascular pedicle to the central sternocostal segment of the pectoralis major muscle is the inferior, pectoral branch of the thoracoacromial artery which proximally runs deep to the muscle. Preservation of this blood supply is important for future reconstruction [11]. Innervation of the pectoralis major muscle is dual; medial and lateral pectoral nerves. This is important to avoid denervation of the sternocostal segment during elevation of the clavicular head [12]. There are studies describing different configurations of pectoralis major muscle, but in our series all patients received rotation advancement without release of the humeral head in case of ipsilateral flaps and with release in case of contralateral flaps [13–15]. Use of pectoralis major muscle flap after complete detachment of its origin and insertion has also been described [16].

The postoperative functional deficits following pectoralis muscle transfer were once considered minimal [17–19]. Functional outcomes of the shoulder after flap have been studied utilizing the QuickDash tool and no deficits have been reported [20]. This is because the upper sternocostal unit is an independent functional unit [21]. The clavicular head helps medial arm rotation when the arm is in a neutral position, while the sternocostal part assists with medial rotation when in adduction. Loss of the clavicular segment of the pectoralis major muscle may decrease the ability to touch the contralateral shoulder without simultaneous arm adduction. However, since the pectoralis major muscle works simultaneously with other shoulder muscles, it does not cause any shoulder instability [22]. None of our patients reported any major shoulder functional deficit at an average follow up of 31 months.

Latissimus dorsi is the next local flap option for closure of sternoclavicular joints. This is a type V flap which consists of a large vascular pedicle, and known secondary pedicles. The thoracodorsal artery is the main pedicle, with secondary pedicles from the posterior intercostal artery. Innervation is through the thoracodorsal nerve [23]. If pectoralis major muscle is not available because of pedicle sacrifice, or there is need for skin paddle, or there is need for more bulk in addition to the pectoralis major, then we recommend latissimus dorsi based on thoracodorsal pedicle. Although skin graft can be performed over pectoralis muscle flap, in our experience bringing skin paddle with latissimus dorsi is more aesthetically pleasing and potentially offers faster recovery. The functional deficit following latissimus dorsi flap is insignificant [24]. The two patients who needed latissimus dorsi flaps in our series were because of the unavailability of the pectoralis major muscle from previous operations, including one patient who needed skin paddle resulting from debridement of the skin

If neither pectoralis major muscle nor latissimus dorsi are available, then a viable third choice is rectus abdominis muscle flap in vertical configuration as VRAM based on the internal mammary artery. Unreliability of the internal mammary must be kept in mind while considering this flap. Given the availability of the pectoralis major muscle and latissimus dorsi, we never had to use this flap, but we do recommend it as a rescue option in case of failure [25]. Free tissue transfers from distant sites are an option of last resort, however we do not have any experience with it to

report. Although free flaps have been described for chest wall reconstruction, its use for sternoclavicular joint has not yet been reported [26]. We recommend using muscle flap as opposed to fasciocutaneous flap [9].

SC joint wounds resulting from infection have previously been classified by Joethy et al. in 2012. This study described their classification system and treatment algorithm, but unfortunately has a small sample size, and did not report group comparisons [4]. For reconstructive procedures, a meta-analysis has elaborated on use of the pectoralis major muscle in several different configurations to close the sternoclavicular wound following resection of the joint. It does not consider use of other flaps, or the extent of resection [27].

This is a retrospective study with focus to find out wound related factors that could point towards reconstructive planning. Limitations of this work include the fact that this data has been collected over a period of 14 years with involvement of several surgeons from different disciplines, i.e. thoracic and plastic surgery. Often plastic surgery's involvement occurred after the initial resection had already occurred and therefore factors relating to preoperative assessment of SC joint osteomyelitis in determining ideal reconstruction could not be studied. The sample size in the study allowed us to run group comparisons and derive powered results. However, the sample size was still not large enough to identify independent risk factors which could potentially be used in a preoperative risk scoring system to help surgeons guide in reconstruction.

Conclusions

Reconstruction following resection of the SC joint with and without the adjacent ribs for septic arthritis are not the same. Reconstruction following resection of the SC joint for septic arthritis is guided by the surgeon's impression regarding source control of infection. Rib resection concomitantly with joint resection appears to be a useful indicator of disease extent and may help guide clinical decision making in this challenging scenario. Future studies to assess preoperative risk assessment tools such as clinical and/or radiologic grading of severity to predict optimal outcomes and reconstruction options are warranted and are being developed by our group.

Disclosure statement

The authors have no conflict of interest to report.

IRB Approval Date and Number: 11/5/2018 and INST# 12-389.

References

[1] Ross JJ, Shamsuddin H. Sternoclavicular septic arthritis: review of 180 cases. Medicine (Baltimore)). 2004;83(3): 139–148.

[2] Ali B, Shetty A, Qeadan F, Demas C, Schwartz JD. Sternoclavicular Joint Infections: Improved Outcomes With Myocutaneous Flaps. Semin Thorac Cardiovasc Surg. 2020 Summer;32(2):369–376.

[3] Ali B, Shetty A, Borah G, et al. Successful management of sternomanubrial joint septic arthritis with pectoralis muscle flap closure: a case series. J Surg Case Rep. 2020;2020(4): rjaa035.

[4] Joethy J, Lim CH, Koong HN, et al. Sternoclavicular joint infection: classification of resection defects and reconstructive algorithm. Arch Plast Surg. 2012;39(6):643–648.

[5] Song HK, Guy TS, Kaiser LR, et al. Current presentation and optimal surgical management of sternoclavicular joint infections. Ann Thorac Surg. 2002;73(2):427–431.

[6] Burkhart HM, Deschamps C, Allen MS, et al. Surgical management of sternoclavicular joint infections. J Thorac Cardiovasc Surg. 2003;125(4):945–949.

[7] Puri V, Meyers BF, Kreisel D, et al. Sternoclavicular joint infection: a comparison of two surgical approaches. Ann Thorac Surg. 2011;91(1):257–261.

[8] Abu Arab W, Khadragui I, Echavé V, et al. Surgical management of sternoclavicular joint infection. Eur J Cardiothorac Surg. 2011;40(3):630–634.

[9] Gosain A, Chang N, Mathes S, et al. A study of the relationship between blood flow and bacterial inoculation in musculocutaneous and fasciocutaneous flaps. Plast Reconstr Surg. 1990;86(6):1152–1162. Discussion 1163.

[10] Freeman JL, Walker EP, Wilson JS, et al. The vascular anatomy of the pectoralis major myocutaneous flap. Br J Plast Surg. 1981;34(1):3–10.

[11] Manktelow RT, McKee NH, Vettese T. An anatomical study of the pectoralis major muscle as related to functioning free muscle transplantation. Plast Reconstr Surg. 1980;65(5): 610–615. e

[12] Corten EM, Schellekens PP, Bleys RL, et al. The nerve supply to the clavicular part of the pectoralis major muscle: an anatomical study and clinical application of the function-preserving pectoralis major island flap. Plast Reconstr Surg. 2003;112(4):969–e75.

[13] Zehr KJ, Heitmiller RF, Yang SC. Split pectoralis major muscle flap reconstruction after clavicular-manubrial resection. Ann Thorac Surg. 1999;67(5):1507–1508.

[14] Schulman MR, Parsons BO, Lin H, et al. Islandized hemipectoralis muscle flap for sternoclavicular defect. J Shoulder Elbow Surg. 2007;16(6):e31–e34.

[15] Al-Mufarrej F, Martinez-Jorge J, Carlsen BT, et al. Use of the deltoid branch-based clavicular head of pectoralis major muscle flap in isolated sternoclavicular infections. J Plast Reconstr Aesthet Surg. 2013;66(12): 1702–1711.

[16] Opoku-Agyeman J, Perez S, Behnam A, Matera D. Reconstruction of sternoclavicular defect with completely detached pectoralis major flap. J Surg Case Rep. 2019 Apr 24;2019(4):rjz122.

[17] Kroll SS, Goepfert H, Jones M, et al. Analysis of complications in 168 pectoralis major myocutaneous flaps used for head and neck reconstruction. Ann Plast Surg. 1990;25(2): 93–97.

[18] Ord RA. The pectoralis major myocutaneous flap in oral and maxillofacial reconstruction: a retrospective analysis of 50 cases. J Oral Maxillofac Surg. 1996;54(11): 1292–1295.

[19] Vartanian JG, Carvalho AL, Carvalho SM, et al. Pectoralis major and other myofascial/myocutaneous flaps in head and neck cancer reconstruction: experience with 437 cases at a single institution. Head Neck. 2004;26(12): 1018–1023.

[20] Kachala SS, D'Souza DM, Teixeira-Johnson L, et al. Surgical management of sternoclavicular joint infections. Ann Thorac Surg. 2016;101(6):2155–2160. Jun

[21] Tobin GR. Pectoralis major segmental anatomy and segmentally split pectoralis major flaps. Plast Reconstr Surg. 1985;75(6):814–824. e24.

[22] Nahai F, Morales L, Jr, Bone DK. et al. Pectoralis major muscle turnover flaps for closure of the infected sternotomy wound with preservation of form and function. Plast Reconstr Surg. 1982;70:471–474.

[23] Mathes SJ, Nahai F. Classification of the vascular anatomy of muscles: experimental and clinical correlation. Plast Reconstr Surg. 1981;67(2):177–187.

[24] Paolini G, Amoroso M, Pugliese P, et al. Functional sequelae following bilateral mastectomy and immediate reconstruction with latissimus dorsi flap: medium-term follow-up. J Plast Surg Hand Surg. 2014;48(2):99–103.

[25] Lee CH, Hsien JH, Tang YB, et al. Reconstruction for sternal osteomyelitis at the lower third of sternum. J Plast Reconstr Aesthet Surg. 2010;63(4):633–641.

[26] Cordeiro PG, Santamaria E, Hidalgo D. The role of microsurgery in reconstruction of oncologic chest wall defects. Plast Reconstr Surg. 2001;108(7):1924–1930.

[27] Opoku-Agyeman J, Matera D, Simone J. Surgical configurations of the pectoralis major flap for reconstruction of sternoclavicular defects: a systematic review and new classification of described techniques. BMC Surg. 2019; 19(1):136.