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Authors: José M. Mora, Simon Lambert

QUESTION 2: Is there a role for resection shoulder arthroplasty in the management of subacute or chronic periprosthetic joint infection (PJI)?

RECOMMENDATION: The available literature does not support specific indications for resection arthroplasty for subacute or chronic shoulder PJI with sufficient quality information to provide guidance. Resection arthroplasty is an acceptable salvage treatment to eradicate shoulder PJI when revision to a definitive implant is considered too risky due to patient medical co-morbidities or technical complexity.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 95%, Disagree: 0%, Abstain: 5% (Unanimous, Strongest Consensus)

RATIONALE

There are no prospective studies or randomized trials on this topic, and all published reports are retrospective case series. In addition, many of these case series include no other cohort to directly compare against any other form of treatment strategy for infected shoulder arthroplasty. The available literature is further limited by the fact that all published series examine outcomes using a variety of methods: (a) pain relief, recorded either as a subset of a score, e.g., the Constant-Murley (CMS) or American Shoulder and Elbow Surgeons (ASES) scores, or as a visual analog scale (VAS); (b) function, recorded either as a subset of a score, or by direct description; (c) management of infection, recorded as either "eradicated," "recurrent" or "persistent" (with no clear definition on how these categories was diagnosed/confirmed).

The systematic review of management strategies for shoulder PJI by George et al. [1] found 8 papers (total number of cases, 83) relating to the use of resection arthroplasty. The number of cases reported per series varied between 5 and 21 with a mean duration of follow-up of post-resection 39.8 months (standard deviation 20.8), minimum 19.2 (9.4), maximum 102.6 (41.9). The number of infections considered eradicated was 72/83 (86.7%) with no difference (statistical or clinically meaningful) in infection eradication observed between resection, single-stage, two-stage and permanent spacer arthroplasty. Preoperative and postoperative functional scores were incompletely reported. Single-stage revision cases had better preoperative scores than other groups, and better outcomes. It should be noted that patients reported worse functional scores (CMS) after surgery than before surgery, particularly for resection arthroplasty. There was no consistency in the choice or duration of antibiotic administration after surgery. Importantly, the authors pointed out that the limited quality of the available literature meant that it was not possible to provide a conclusion concerning the indication for one modality over another if the aim of intervention was to eradicate infection while optimizing the functional outcome for patients.

When reviewing the available literature, it should be noted that the majority of PJI for which resection is reported as an outcome are reverse total shoulder arthroplasties [2–4]. It is not clear whether this relates to the more challenging reconstructions often encountered after revision reverse total shoulder arthroplasty (TSA) or perhaps the nature of the reverse TSA patient population who tend to have more medical comorbidities and lower functional demands.

Patient outcomes including eradication of infection, pain relief and function were reported using variable standards. The concept that resection arthroplasty carries the advantage of being "one final surgery" should be tempered by the results showing that, on average, two debridements were required for infection to be clinically eradicated (mean follow-up 20 months) [5]. Braman et al. [5] showed that in their series of seven patients, while the functional scores were generally poor, all patients were able to perform activities between the mouth, opposite axilla and perineum and were satisfied with the outcome. Other authors, however, have shown that patient satisfaction is poor overall. Rispoli et al. reported one-third of cases falling into the lower third of categories for satisfaction, and 16 of 18 cases having an unsatisfactory outcome by Neer criteria [6]. If preoperative impairment was not substantial (defined as a CMS of greater than 30) then there was no significant improvement after surgery [2]. The same authors considered that reimplantation (whether one- or two-stage) delivered better functional outcomes than resection arthroplasty [2]. Zavala et al. (2012) concluded that resection was inferior to a debridement, antibiotics, irrigation and implant retention (DAIR) strategy in providing for function without increasing the risk of persistent or recurrent infection at a minimum of 12 months follow-up, while also commenting that implant retrieval lead to (potentially) revision-limiting bifocal bone loss [7]. DeBeer et al. recommended resection be indicated for the elderly with PJI and with lower functional expectations [8]. A single comparative study comparing resection with staged reimplantaion demonstrated that there was benefit for range of motion if a staged reimplantation could be safely undertaken with no increased risk of persistent or recurrence of infection [9]. This study was presented at the American Academy of Orthopaedic Surgeons (AAOS) and does not appear to have been published elsewhere. Resection arthroplasty for subacute or chronic PJI may some provide pain relief in approximately one-third to one-half of cases [3,6,7,10–12].

There are some technical and prognostic factors which may effect patient functional outcome and satisfaction. Retention of the tuberosities appears useful for function, possibly by reducing the tendency for proximal humeral migration [12]. In addition, there is some debate regarding how an antibiotic spacer may compare with resection alone with respect to eradication of infection and function. Verhelst et al. reported that use of a spacer (permanent

TABLE 1. Articles specifically concerning resection arthroplasty in shoulder PJI, with details as noted

Author	Year	n	Failed	CMS	SST	Surgery Prior to Resection (N)	VAS	ASES	FE	Abd	ER
Verhelst	2011	11E	2/11	40.4			2.6		85.5°	78.1°	21°
		10 EAS									
Rispoli	2017	18 E			3.1		4.5	36	70°		31°
Stevens	2015	4 E	1/4		3.3	2 cases = 3 2 cases > 5	8.8	20.8	63°		25°
		4 EAS	0		6	1.5	0.4	69	85°		30°
Maynoud	2006	10 E	0	28							
Braman	2006	7 E	0			2.2			28°		8°
Ghijselings	2013	8 E		27.8	2.4		3.6				
		5 EAS		20.6	1		6				

NB: many data are incomplete since not all ideal data were recorded by the authors (see [6]). In three studies there are comparison cases of explantation and antibiotic spacer (EAS) and explantation alone (E) [1,13,14,16].

or temporary) did not appear to compromise eradication of infection but also did not necessarily confer benefit for function or pain relief postoperatively [13]. In contrast, Ghijselings in a comparative series evaluating resection with resection plus antibiotic-impregnated spacer reported a differential benefit for spacer with regard to domestic activities, but overall functional scores and pain relief were no different [14]. In the setting of bilateral pathology, Ueda et al. concluded there is improved function for domestic activities with bilateral retained antibiotic spacers when compared with historical reports of resection arthroplasties for PJI [15].

In summary, the functional result is relatively poor, but the eradication of infection is quite good (86.7%), especially considering that in these non-randomized studies patients with resection arthroplasty are likely frail and/or have difficult to treat pathogens [1]. It remains unclear whether a resection arthroplasty is preferred versus a retained antibiotic-impregnated cement spacer, with some studies suggesting a modestly better functional result with the spacer. Resection arthroplasty is an acceptable salvage treatment when revision to a definitive implant is considered too risky due to patient medical co-morbidities or technical complexity of revision surgery.

Search Strategy

A request via the Royal Society of Medicine Library utilising ProQuest Dialog, searching Embase and Medline archives with search terms (excision arthroplasty) OR (resection arthroplasty) AND (acute periprosthetic infection) OR (chronic periprosthetic infection) OR (subacute periprosthetic infection) yielded 1649 references. After limiting these to shoulder-specific references and eliminating duplicates, 100 references were further searched for exact matching to the question of the role of resection arthroplasty in the management of subacute/chronic PJI (SA/C PJI). All full papers, reviews and abstracts in English between 1990 and 2018 were examined, and those reporting the indications and outcomes of resection (excision) arthroplasty of the shoulder were examined further.

Personal searches of PubMed archives were performed by both authors using the same criteria, and their searches were compared. The bibliographies of two recent reviews (one specifically examining the question of resection, the value of spacers and one-and two-stage revision arthroplasty in subacute/chronic PJI [1], the other a more general review [17]) were examined for further references and cross-checked with the first enquiry and the personal searches. This strategy was compared with that of the most useful review [1] for completeness.

In Stevens et al. [16], there were seven patients available – eight cases (four explantation and four explantation and antibiotic spacer). In mobility there were three cases with data not available. In relation to "failed," there was only one case following explantation alone, which equates to 25% as a proportion of the group, or 12.5% as a proportion of all cases in this series.

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3.7. TREATMENT: REVISION

Authors: Mandeep Virk, Iván Encalada, Gerald Williams

QUESTION 1: Is there a role for an antibiotic spacer for the treatment of shoulder periprosthetic joint infection (PJI)?

RECOMMENDATION: An antibiotic loaded cement spacer may be used as part of a shoulder two-stage exchange arthroplasty for local delivery of high concentration of antibiotics. An antibiotic loaded cement spacer may be used as a definitive/permanent treatment option in select cases.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

Antibiotic loaded cement spacers can be used in the management of infected shoulder arthroplasty [1–4]. The antibiotic loaded cement spacer delivers antibiotics to the local tissues, eliminates dead space, maintains soft tissue tension and shoulder function and is used for these reasons as a temporary spacer in two-stage reimplantation for infected shoulder arthroplasty [2,3]. Less commonly, it can be considered as a permanent/definitive spacer if the patient declines further surgery or if the patient is not a good surgical candidate for the second stage of two-stage reimplantation (e.g., sick patient, significant bone loss) [5–8].

The role of antibiotic loaded cement spacer in shoulder PJI has been studied previously in retrospective cohort studies (Table 1). An antibiotic loaded cement spacer is indicated as a temporary spacer in the two-stage treatment of shoulder PJI in conjunction with intravenous antibiotics [2,3]. However, use as a definite/permanent spacer has also been described as a treatment for patients who are a high surgical risk or refuse second stage of two-stage treatment [5–7]. Jawa et al. reported a retrospective review of 28 patients with infected shoulder arthroplasty who were managed with antibiotic loaded cement spacer [2]. Sixteen patients underwent a two-stage operation, and twelve patients declined second stage procedure. Five patients had recurrence of infection (18%), and 5 patients had severe pain (18%) at final follow up. Complications with the use of cement spacer included dislocation (1 patient) and fracture (3 patients). Torrens et al. reported a culture positive rate of 13.6% (3 shoulders) from 22 antibiotic loaded cement spacers retrieved during second stage reimplantation [9]. In contrast to studies by Jawa et al. and Torrens et al., other investigators have reported lower rates of recurrence of infection with antibiotic loaded cement spacer use. Pellegrini et al. reported no recurrence of infection with a definitive antibiotic spacer in a cohort of 19 low demand, elderly subjects who had infected shoulder arthroplasties [6]. At a mean follow up of 8 years, all patients reported satisfactory subjective and objective outcomes. One patient had glenoid osteolysis with no adverse effect on functional outcome. Levy et al. retrospectively reviewed outcomes in 9 patients with infected shoulder arthroplasty who elected to not have the second stage reimplantation [7]. These patients had acceptable function with their antibiotic spacers at a mean follow up of 25 months. There was no recurrence of infection (0%) and only one patient (11%) was unsatisfied with the results. Mahure et al. reported no recurrence of infection (0%) in a retrospective case series of patients with shoulder PJI who received an antibiotic loaded cement spacer as definitive treatment after first stage of the two-stage treatment [5,10]. In a retrospective study, Romano et al. reviewed 44 patients with infected shoulder arthroplasty of which 32 patients had treatment with a temporary or permanent antibiotic loaded spacer [11]. There was one recurrence of infection in the definitive spacer group. Lee et al. used an antibiotic loaded cement spacer for the first stage implantation in 12 patients with infected shoulder arthroplasty. All patients received intravenous antibiotics followed by the second stage treatment [12]. There was no recurrence of infection (0%) at mean follow up of 41 months. Improved functional outcomes with the use of antibiotic loaded cement spacer was reported by Jerosch et al. in a retrospective review of 10 patients with shoulder PJI [13]. Patients were able to perform physical therapy with the antibiotic spacer in situ, and 8 patients underwent second stage with no reported recurrence of infection.

There is no consensus on the optimal class of antibiotics to be used in spacer preparation. Heat stable antibiotics (vancomycin, gentamycin and tobramycin) have been used alone or in combination. Spacer design and patient-specific anatomic features have also been studied with regards to infection clearance and patient satis-