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TRAUMA SURGERY

Prepatellar and olecranon bursitis: literature review and development of a treatment algorithm

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Abstract
Purpose Olecranon bursitis and prepatellar bursitis are common entities, with a minimum annual incidence of 10/100,000, predominantly affecting male patients (80 %) aged 40–60 years. Approximately 1/3 of cases are septic (SB) and 2/3 of cases are non-septic (NSB), with substantial variations in treatment regimens internationally. The aim of the study was the development of a literature review-based treatment algorithm for prepatellar and olecranon bursitis.
Methods Following a systematic review of Pubmed, the Cochrane Library, textbooks of emergency medicine and surgery, and a manual reference search, 52 relevant papers were identified.
Results The initial differentiation between SB and NSB was based on clinical presentation, bursal aspirate, and blood sampling analysis. Physical findings suggesting SB were fever >37.8 °C, prebursal temperature difference greater 2.2 °C, and skin lesions. Relevant findings for bursal aspirate were purulent aspirate, fluid-to-serum glucose ratio <50 %, white cell count >3,000 cells/μl, polymorphonuclear cells >50 %, positive Gram staining, and positive culture. General treatment measures for SB and NSB consist of bursal aspiration, NSAIDs, and PRICE. For patients with confirmed NSB and high athletic or occupational demands, intrabursal steroid injection may be performed. In the case of SB, antibiotic therapy should be initiated. Surgical treatment, i.e., incision, drainage, or bursectomy, should be restricted to severe, refractory, or chronic/recurrent cases.
Conclusions The available evidence did not support the central European concept of immediate bursectomy in cases of SB. A conservative treatment regimen should be pursued, following bursal aspirate-based differentiation between SB and NSB.

Keywords Olecranon · Prepatellar · Bursitis · Bursectomy · Bursal aspiration

Introduction

There are more than 140 bursae within the human body [83]. Bursae are closed sacs lined by a synovial membrane providing almost frictionless motion between two tissue layers. Bursae develop after birth, most likely in response to movement and function [4, 12]. In the literature, olecranon and prepatellar bursitides were usually considered similar conditions, which is also the case in this paper.

Bursitis accounts for approximately 1–12 cases per 10,000 hospitalizations with a reported minimum population annual incidence of 10/100,000. More than 80 % of all bursitis patients are male, aged 18–88 years, clustering at 40–60 years [11, 40, 43, 55, 56, 66, 68, 72]. Approximately 2/3 are non-septic cases and septic olecranon bursitis occurs four times as often as septic prepatellar bursitis [31, 40, 50, 70].

Non-septic bursitis (NSB) is a sterile inflammation that develops secondary to acute, occupational, or recreational trauma, crystal deposition (gout, pseudogout), or systemic

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disease, such as rheumatoid arthritis, systemic lupus erythematosus, or uremia [31, 44, 70]. Most cases of NSB are posttraumatic or due to overuse, either in athletes (ice hockey, volleyball, or wrestling) or occupational groups at risk (carpenters, gardeners, roofers, and heavy learning students) [44, 45, 47, 50, 81]. Trauma triggers an acute inflammatory response with an overproduction of bursal fluid and subsequent bursal swelling, resulting in NSB.

Conversely, septic bursitis (SB) is most often a bacterial infection of the bursal sac, more frequently caused by skin lesions, or secondary spread from initial cellulitis into a pre-traumatized superficial bursa, rarely by hematogenous seeding [9, 25, 32, 33, 44, 50, 59, 68]. Because of their superficial and exposed location, the olecranon and prepatellar bursae are the most common sites for SB [7, 32]. Infection is commonly caused by bacteria [9, 21, 32, 33, 41, 55, 68, 72] and rarely by fungi or the *Prothotheca* sp. of algae [10, 53, 65]. Up to 50 % of all SB cases occur in immunocompromised patients [21, 25, 55, 70]. Other risk factors include rheumatic chronic inflammatory conditions, profession presenting a risk of trauma, or positive history of SB [32, 43, 44, 70, 83]. In rare cases, mostly far advanced cases, SB might cause massive necrosis of the skin and severe infection of the surrounding soft tissue.

Although olecranon and prepatellar bursitides are common, the number of studies available is limited, with varying treatment internationally. While recently published treatment guidelines [1, 18, 29] as well as the limited literature available argue for a conservative treatment approach in SB and NSB [25, 34, 43], two recent epidemiological studies among Austrian [2] and Swiss orthopedic surgeons [3] surveyed a predominantly surgical treatment approach in the case of SB, which is in line with the recommendations of the German Paul-Ehrlich-Gesellschaft [54]. Moreover, although most authors agree that initial differentiation between SB and NSB is the silver bullet to any successful treatment, differentiation remains a common and significant problem. To the authors' best knowledge, no study has tried to develop a best-evidence treatment algorithm based on the literature available.

Aim

The aim of the current study was to review evidence on prepatellar and olecranon bursitis and consequently develop a best-evidence treatment protocol for these conditions.

Methods

First, a systematic literature review was conducted. Pubmed, the Cochrane Library, and textbooks of emergency medicine and surgery, as well as manual references, were searched for publications between 1950 and 06/2013. Pubmed and the Cochrane Library were searched for "bursitis" in combination with "olecran*" or "prepatellar*." Fifty-five papers, no Cochrane reviews, and six textbooks were included in the final analysis. Each paper was rated for its level of evidence (LoE), according to the guidelines published by the Oxford Center of Evidence-based Medicine (March 2009). Based on the literature review and LoE, a best treatment algorithm for prepatellar and olecranon bursitides was developed. The algorithm was based on a list of criteria, highly indicative or diagnostic for SB. The thresholds for the criteria were chosen to favor the diagnosis of SB. A modified flow chart layout was used to outline the algorithm [36].

Results

An algorithm should quickly guide a probable diagnosis and subsequent treatment. While acute and chronic bursitis is easily distinguishable, differentiation between SB and NSB is difficult. Still, the silver bullet in the treatment of bursitis is the initial differentiation between SB and NSB. The final best-evidence treatment algorithm for SB is presented in Fig. 1.

Diagnostics

Diagnostics consist of physical findings, radiographs, ultrasounds, bursal fluid aspirate analysis, and blood sampling [15, 32, 44, 46, 66, 70, 72]. The relevant diagnostic criteria were identified and are outlined in the following sections. All cutoff values were chosen to favor the diagnosis of septic bursitis. Table 1 summarizes the final decision criteria.

Clinical presentation

Differentiation between SB and NSB on clinical presentation alone was found to be difficult owing to a considerable overlap in physical findings [31, 32, 44, 67, 76]. Commonly reported symptoms are swelling, redness, bursal warmth, and tenderness. Bursal swelling, redness, and tenderness were found to be inadequate to differentiate between SB and NSB. Fever has exclusively been reported for SB [25, 40]. Therefore, any bursitis accompanied by fever (>37.7 °C) should be considered infected (LoE: 2b). In most retrospective studies, bursal warmth was a rather nonspecific criterion [31, 40, 59]. However, Smith et al. [66] performed a prospective blinded analysis of 35 nonseptic and 11 septic cases of olecranon bursitis and found a temperature difference of ≥2.2 °C between the affected

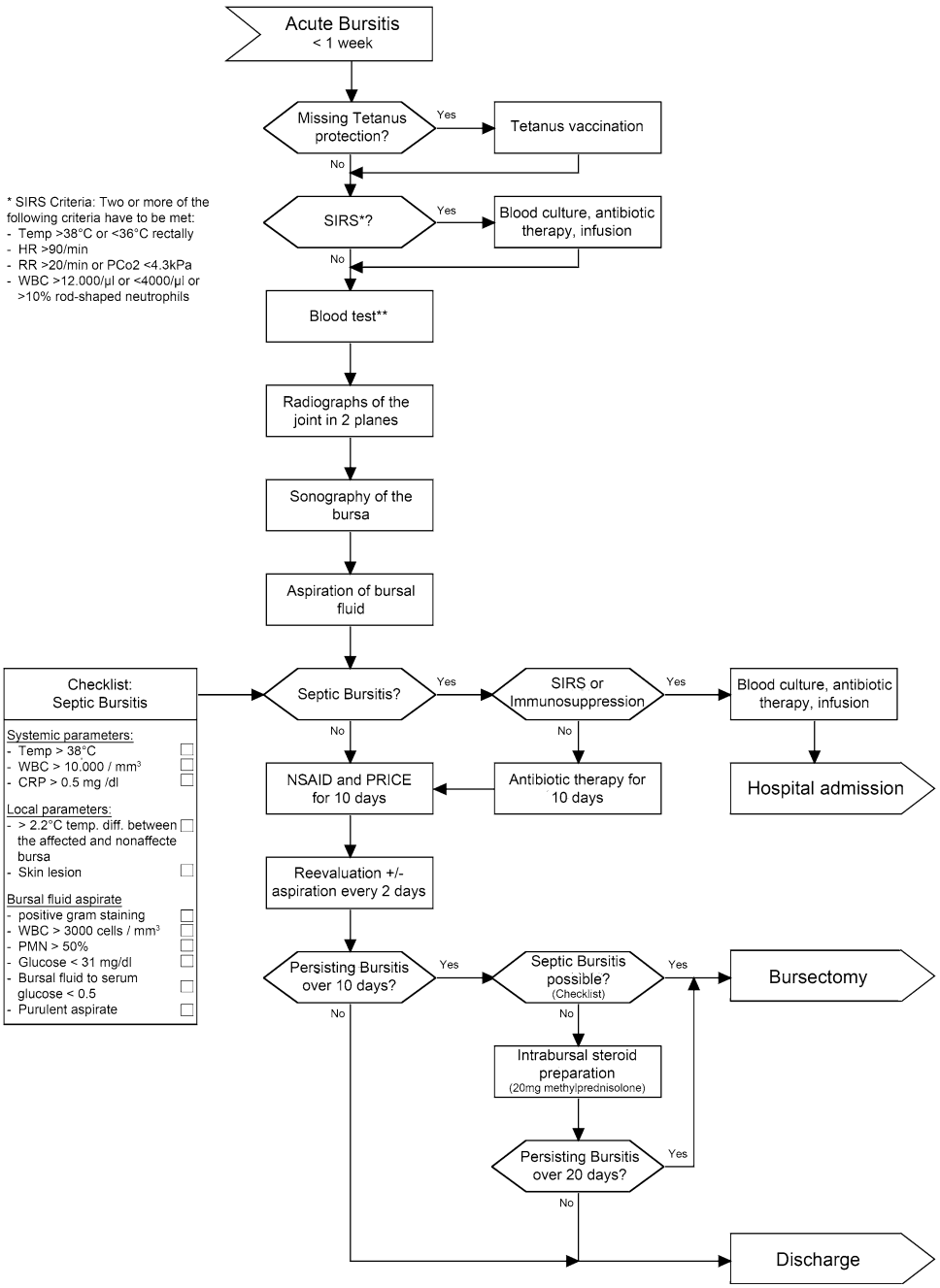

Fig. 1 Treatment algorithm for acute septic and non-septic olecranon and prepatellar bursitides based on the current literature

and contralateral bursae to be 100 % sensitive and 94 % specific for SB. Bursal warmth was therefore considered a decision criterion (LoE: 1b). Because of the superficial location of both bursae, any skin lesion is predisposed to a bacterial migration into the bursal sac. Skin lesions can either be traumatic or dermatologic, such as eczema, stasis dermatitis, or psoriasis. Patients presenting with skin lesions were found to have significantly higher rates of septic bursitis [31, 66] (LoE: 2b).

Imaging

Prior to aspiration, standard radiographs in 2 planes and ultrasound should be conducted. Radiographs may reveal

Table 1 Values favoring SB

	Parameters	Values
Clinical presentation	Fever (>37.7 °C)	Positive
	Bursal warmth	>2.2° temp. diff.
	Skin lesion	Positive
Aspirate	Gross fluid characteristics	Purulent aspirate
	White cell count	>3,000 cells/μl
	Glucose	<31 mg/dl[a]
		<50 %[b]
	PMN	>50 %
	Gram staining	Positive
Blood sample	Leukocytes, CRP	Elevated

[a] Bursal fluid glucose

[b] Bursal fluid-to-serum glucose

Table 2 SIRS criteria [6]

Two or more of the following criteria have to be met for SIRS
Temp >38 °C or <36 °C rectally
HR > 90/min
RR > 20/min or PCo_2 < 4.3 kPa
WBC >12,000/μl or <4,000/μl or >10 % rod-shaped neutrophils

Temp temperature, *HR* heart rate, *RR* respiratory rate, and *WBC* white blood cells

bone lesions, spurs, or osteomyelitis [32, 50]. Ultrasound helps to further characterize the structure/content of the bursa, possibly detecting loose bodies and rheumatoid nodules as well as gout tophi as possible underlying causes [5].

Bursal aspirate

Any case of suspected bursitis should be aspirated. Gross fluid characteristics give a first hint to the etiology. While clear, milky, or hemorrhagic aspirate indicates NSB [15, 56, 83], purulent aspirate indicates SB [70, 83]. Most studies on SB have assessed white cell count (WCC). Based on the numbers available in the literature, the authors calculated a mean WCC ± SD of 2,475 ± 1,988 cells/μl (range 0–11,700 cells/μl) for non-septic bursitis [31, 66, 72, 80] and 54,350 ± 34,197 cells/μl (range 350–392,500 cells/μl) for septic bursitis [9, 25, 31, 32, 43, 56, 59, 60, 66, 76]. Based on these values, a WCC greater than 3,000 cells/μl was considered indicative of SB (LoE: 2a). Bursal fluid glucose, or bursal fluid-to-serum glucose ratio, may also be altered in the presence of infection. A mean bursal glucose of 86 ± 23 mg/dl (70–80 % fluid-to-serum ratio) in cases of NSB and 32 ± 39 mg/dl (<50 % fluid-to-serum ratio) in cases of SB was found in the literature [25, 31, 44, 66]. Consequently, a total bursa fluid glucose lower than 31 mg/dl or a fluid-to-serum ratio less than 50 % was considered a decision criterion (LoE: 2b). Polymorphonuclear cell (PMN) ratios greater than 50 % were commonly reported in cases of SB [31, 32, 44, 59, 66, 76] and were therefore considered indicative of SB (LoE: 2b). One of the most specific tests on bursa fluid aspirate is Gram staining, which, if positive, is diagnostic of bacterial infection (LoE 1a). A bursal fluid culture in liquid media should be obtained to verify the diagnosis of NSB/SB and to reevaluate the effectiveness of the chosen antibiotic (LoE 1a). The advantage of the parameters proposed here is their availability, as they are similar to those assessed for arthrocentesis.

Blood sample

Blood samples should be drawn from any patient presenting with suspected bursitis. In the case of elevated infection parameters (CRP, Leukocytes), SB can be assumed. Patients with considerably elevated infection parameters, SIRS (Table 2), or immunosuppression should be hospitalized.

Treatment

Following initial classification into SB or NSB, adequate treatment should be initiated. In general, a conservative therapeutic approach for SB and NSB should be pursued [44, 46, 62, 80]. A conservative treatment approach is obviously limited to moderate cases of SB. Critically ill patients and cases of severe SB with necrosis of the overlying skin or accompanying severe infection of the surrounding soft tissue, i.e., phlegmon, necessitate immediate surgical intervention [1]. Table 3 shows a comprehensive summary of available treatment and outcome data. Two-thirds of the studies were conducted before the year 2000 and are mostly retrospective with heterogeneous treatment regimens.

Conservative therapy

General therapeutic measures consist of bursal aspiration, PRICE, and NSAID. Bursal aspiration relives pain, increases ROM, reduces bacterial load, and has been recommended for both NSB [34, 37, 44, 46, 67, 70] and SB (LoE: 2a) [9, 25, 27, 30, 32, 39, 40, 43, 44, 46, 50, 56, 59, 62, 72, 76, 81, 83]. Aspiration should be repeated if bursal fluid reaccumulates [9, 13, 15, 30, 32, 39, 44, 46, 76, 80, 81]. In severe cases of SB, aspiration can be performed as often as daily [25, 27, 43, 44, 62]. The PRICE scheme, which consists of **P**rotection, **R**est (+immobilization), **I**ce, **C**ompression, and **E**levation has been recommended for

Table 3 Comprehensive summary of available treatment and outcome data

References	Dsg	Location	Type	*N*	Age	Therapy	Outcome	Complications
Conservative/surgical								
Ho et al. [32]	RS	O (80 %) P (20 %)	SB	25	47	General treatment: i.v. AB followed by oral AB Prepatellar bursitis: 2 cases incision and drainage, 3 cases serial bursal aspirates	Duration of symptoms: 6.1 ± 6.4 d	4 cases responded, needed i.v. AB 1 case underwent bursectomy
Canoso and Sheckman [9]	RS	O (75 %) P (12.5 %) I (12.5 %)	SB	16	53	SBA ± incision +i.v AB + immobilization	Time to recovery: 31.8 ± 44.2 d All cases recovered	2 cases with chronic drainage - 1 case resolved spontaneously - 1 case required bursectomy
Hoffmeyer et al. [33]	RS	O	SB	17	41	Initial AB Symptoms >72 h after therapy → bursectomy	n.s.	6 cases required incision and drainage - 2 cases of delayed wound healing
Ho and Su [30]	PS	O (84 %) P (12 %) I (4 %)	SB	25	50	Severe infection: hospitalization, SBA, i.v. AB Moderate/mild infection: outpatient, oral AB, SBA	Time to sterile bursal aspirate: 4 d 25 cases full recovery	n.s.
Weinstein et al. [80]	RS	O	NSB	22	59	Single bursal aspiration	Delayed recovery	2 cases with chronic pain
				25	56	SBA + intrabursal corticosteroids	Rapid recovery	3 cases of septic bursitis 5 cases of skin atrophy 7 cases of chronic pain
Söderquist and Hedstrom [68]	RS	O (31 %) P (69 %)	SB	35	47	SBA + i.v. AB 8 cases incision	29 cases no sequel, no relapse	1 case extensive subcutaneous abscess 1 case had a septic coxarthritis at the same time
Roschmann and Bell [60]	RS	O (59 %) P (51 %)	SB	17	41.6	SBA + AB + hospitalization	Time to sterile bursal aspirate: 3.1 d	n.s.
		O (77 %) P (15 %) I (5 %)	SB + IC	12	50.6		Time to sterile bursal aspirate: 11.3 d	n.s.
Raddatz et al. [59]	RS	O (63 %) P (27 %) I (4 %) T (2 %) SD (2 %) M (2 %)	SB	49	49	41 cases aspiration 5 cases initial surgical incision and drainage 37 cases hospitalization + i.v. AB 12 cases outpatient + oral AB - >8 cases later hospitalization + i.v. AB	Time to full recovery: 39 d	1 case with bilateral olecranon SB died of presumed sepsis 1 case of patella osteomyelitis 1 case of chronically draining bursa 2 cases required incision and drainage 2 cases required bursal irrigation procedures

Table 3 continued

References	Dsg	Location	Type	*N*	Age	Therapy	Outcome	Complications
Smith et al. [67]	PS	O	NSB	11	59	Aspiration + compression for 10 d + intrabursal cortisone + NSAID for 10 d	1-week follow-up: intrabursal cortisone injection showed most rapid decrease in swelling	No adverse reactions
				10	59	Aspiration + compression for 10 d + intrabursal cortisone + placebo for 10 d	6-week follow-up: groups oral naproxen and oral placebo required more reaspirations	
				10	62	Aspiration + compression for 10 d + NSAID for 10 d	No adverse reactions	
				11	62	Aspiration + compression for 10 d + placebo for 10 d		
Pien et al. [56]	RS	O (72 %) P (28 %)	SB	47	51	SBA + AB	Complete resolution, no recurrence, no limitations	3 cases required surgical drainage
Stell [70]	PS	O (66 %) P (34 %)	SB	18	33.6	Oral AB for 10 d (outpatient), iv. AB in case of systemic inflammatory signs	Duration of symptoms: - 6.6 weeks for SB olecranon - 3.0 weeks for SB prepatellar	1 case requiring surgical intervention 3 cases developed discharging sinuses
			NSB	20	43	SBA ± NSAID ± intrabursal cortisone (confirmed non-septic, 7 cases)	Duration of symptoms: - 6.7 weeks for NSB olecranon - 3.8 weeks for NSB prepatellar	9 cases no change or worsening
Garcia-Porrua et al. [25]	RS	O (47 %) P (44 %) I (1 %) T (5 %) SA (3 %)	SB	75	50.7	Usual regime: SBA + i.v. AB for 5 d once culture became neg. followed by oral AB for 2 weeks Immunocompromised cases: i.v. AB for 3 weeks, followed by oral AB for 3 weeks	"all cases ultimately recovering completely"	4 cases bursectomy
Laupland et al. [40]	RS	O	SB	118	44	i.v. AB (mean 3 d) followed by oral AB (mean 7 d)	n.s.	51 cases required incision and drainage
Martinez-Taboada [43]	RS	O (27 %) P (73 %)	SB	82	47.2	SBA + hospitalization + i.v AB until improvement, followed by oral AB	Complete resolution in 98.8 %	1 case developed osteomyelitis 5 cases presented side effects (cutaneous rash, etc.) 10 cases required surgery

Table 3 continued

References	Dsg	Location	Type	*N*	Age	Therapy	Outcome	Complications
Perez et al. [55]	RS	O (69 %) P (31 %)	SB	343	51	Bursectomy + i.v. AB (mean 3 d) followed by oral AB; total mean AB time 13 d 31 cases conservative treatment (AB) 142 cases underwent one-stage bursectomy with immediate closure 170 cases initial bursectomy+ - 146 cases, lavage and closure - 24 cases more, then 2 debridements	293 cases achieved clinical cure	50 cases recurrence (out of 31 cases treated conservative, 24 experienced recurrence)
Surgical								
Quayle and Robinson [57]	PS	P	Chronic	8	45.6	New surgical approach: only posterior wall is excised	Return to work within 6 weeks	2 cases damage N. saphenous of ramus infrapatellaris 2 cases mild irritation and discomfort in scar
Quyale and Robinson [58]	PS	O	Chronic	11	53.5	New surgical approach for patients with spurs or abnormally prominent or large olecranon: excision of the olecranon process, bursa is preserved, compression bandage for 20 d	Return to work within 4–6 weeks	Leaning on elbow was uncomfortable for up to 3 months 2 cases Hypoesthesia which resolved within 2 years 2 cases scar tenderness
Knight et al. [39]	RS	O (83 %) P (17 %)	SB	12		Tube drainage–irrigation + i.v. AB + immobilization	Resolution in all 12 cases	n.s.
He and Tice [31]	RS	O (50 %) P (50 %)	SB, NSB	6	n.a.	Initial treatment failed: Aspiration, injection of corticosteroids, compression, padding Endoscopic bursectomy + compression for 2–3 weeks, 1 case knee immobilizer for 2 weeks	2 cases with septic bursitis had residuals	1 case with recurrence (CREST syndrome) 1 case required incision and drainage
Kerr [37]	RS	O (36 %) P (64 %)	SB, NSB	11	n.a.	Initial conservative treatment failed Endoscopic bursectomy ± drain + compression (3 weeks) ± immobilization	n.s.	1 case with continued drainage + scaring of skin 1 case with secondary infection 1 case with recurrence
Stewart et al. [73]	RS	O	NSB	21	50	13 cases bursectomy 8 cases bursectomy + osseous resection 1 cases only osseous resection postoperative compression + immobilization (2–3 weeks)	No rheumatoid arthritis: full relief in 15 out of 16 cases Rheumatoid arthritis: full relief in 2 out of 5 cases	3 cases with reaccurance and revision bursectomy 2 cases with prolonged symptoms

Table 3 continued

References	Dsg	Location	Type	*N*	Age	Therapy	Outcome	Complications
Steinacker and Verdonck [69]	RS	P	Chronic	22	34.5	Endoscopic bursectomy	Return to work within 18 d	1 case with recurrence and bursectomy
Ogilvie-Harris and Gilbart [51]	PS	O (62 %) P (38 %)	Chronic	50	31	Failed treatment with SBA and intrabursal cortisone - Endoscopic bursectomy + compression for 10 d	86 % of olecranon bursectomy no pain 66 % of prepatellar bursectomy no pain	24 % residual tenderness 10 % pain on kneeling 2 recurrences (1 with rheumatoid arthritis, 1 repetitive daily trauma to the knee)
Schulze et al. [61]	RS	O	Chronic NSB	9	54	Failed conservative treatment (SBA + NSAID) - Open bursectomy	Time to return to work: 18 d	4 cases scar pain
				9	53	Endoscopic bursectomy	Time to return to work: 10 d	3 cases scar pain
Nussbaumer [50]	PS	O (69 %) P (31 %)	SB, NSB	13	54	Cases who had failed conservative treatment (AB, immobilization) Endoscopic bursa shaving	Time to recovery: all within 3 weeks No residuals or recurrence	No complications
Degreef and De Smet [17]	RS	O	Chronic SB NSB	37	52	Open bursectomy + immobilization in collar and cuff splint for 10 d + AB in 5 cases	n.s.	10 cases presented with prolonged exudation (31 d) 8 cases of recurrence 1 case required a lateral arm flap
Huang and Yeh [34]	PS	P	Chronic NSB	60	33.5	Failed conservative treatment (SBA + NSAI) + recurrent minor trauma + no underlying systemic disease Endoscopic bursectomy + padding and bandage + NSAID + ice packing for 48 h + rest for 2 weeks	Patients returned to normal activity 3 weeks post OP 80 % no residual pain No recurrence	3 cases required serial aspiration

Studies excluded due to insufficient data or missing follow-up [24, 40, 64, 68]

Dsg study design, *N* number of cases, *Age* age in years, *SBA* serial bursal aspirate, *n.s.* not specified, *RS* retrospective, *PS* prospective, *IC* immunocompromised, *O* olecranon, *P* prepatellaris, *I* infrapatellaris, *T* trochanteric, *SD* subdeltoid, *M* metatarsal, *SA* subacromial, *d* days, *SB* septic bursitis, and *NSB* non-septic bursitis

NSB [15, 45, 46, 48, 50] and SB (LoE: 2a) [32, 46, 50]. The affected limb should be immobilized for about one week [15, 46] and compressive dressings applied for a minimum of 3 days [34, 37, 44, 46, 50, 83]. NSAIDs are well established in the treatment of NSB [15, 34, 44, 50, 70] and SB [15, 46, 50]. Treatment duration should average 10–14 days [44].

Septic bursitis specific therapy

Antibiotic therapy is the key in the treatment of SB. If bursal infection is suspected, empirical antibiotics should be started [13, 27, 43, 46, 50, 62, 70, 71, 83]. 80 to 90 percent of SB is caused by *Staphylococcus aureus*. Antistaphylococcal or antistreptococcal antibiotics, such as penicillinase-resistant penicillin or a first-generation cephalosporin, should consequently be administered initially, unless the Gram stain or other factors, such as allergies, suggest otherwise [9, 31–33, 40, 44, 46, 68, 70, 76, 81]. In mild to moderate cases of SB, antibiotics can be administered orally for 2 weeks on an outpatient basis [30, 32, 43, 46, 56, 70, 71, 83]. In rare cases, other bacteria (such as *Nocardia asiatica* [41], *Brucella abortus* [78] or Mycobacterium kansasii [42]), fungi [10, 65, 74] or the *Prothotheca sp*. of algae [53] have been reported as pathogens [16, 49, 79].

In cases with systemic signs of infection or immunocompromised patients, hospitalization is recommended and antibiotics should be administered intravenously (i.v.) for seven to 10 days, followed by oral antibiotics for up to 2 weeks [25, 31, 32, 43, 44, 46, 56, 70, 71, 83].

Follow-up

Every patient has to be followed up 2 days later. Initial classification into SB/NSB should be verified by bursal aspirate culture results. Furthermore, treatment results, i.e., swelling, redness, and response to antibiotic treatment, have to be evaluated, and the chosen antibiotic treatment has to be reevaluated based on results of the aspirate culture. Regular follow-up visits should be scheduled to monitor treatment progress.

Surgical therapy

Surgical treatment, i.e., drainage or bursectomy, is indicated in cases of SIRS, failed conservative treatment or if complications, such as skin necrosis, fistulas, pointing abscesses, or phlegmon of the surrounding soft tissue, occur [15, 40, 70, 83]. Antibiotics should be administered following any surgical intervention for about 7 days [25, 30, 39, 40, 55].

Drainage

The primary surgical approach in refractory NSB or SB cases is drainage, especially in the case of septic complications [17, 28, 32, 40, 44, 46, 47, 56–59, 64, 73, 81–83]. Reported complications are delayed wound healing, hematoma formation, chronic sinus tract formation, cutaneous nerve damage, and pain, as well as spreading of the infection to healthy surrounding tissues [40, 76, 79, 83].

Bursectomy

Surgical excision of the affected bursa is indicated in critically ill patients, severe soft tissue complications, immunocompromised patients, refractory, or chronic/recurrent NSB and SB cases or failed drainage [15, 17, 20, 25, 27, 34, 37, 46, 48, 50, 52, 57, 67, 69, 70, 73, 79]. Bursectomy can be performed openly or endoscopically and should, if possible, not be performed in an acutely inflamed bursa, since anatomical borders may be difficult to identify [15, 32, 46, 47, 64, 73]. Bursitis-promoting factors such as olecranon spurs should be removed [50, 58]. Following conventional open bursectomy, primary wound closure should be the goal. In cases of extensive purulence and/or necrosis, the incision might be left open and closed secondarily [55]. Reported complications include wound healing problems, chronic scar pain, hypoesthesia, and recurrence [8, 14, 15, 17, 24, 34, 37, 50, 51, 56–58, 69]. Standard bursectomy can be performed on an outpatient basis, except for cases requiring hospitalization, as defined above.

Discussion

The aim of this systematic review was the development of an evidence-based treatment algorithm for prepatellar and olecranon bursitides. Based on the literature review, the authors defined decision criteria for the initial differentiation between NSB and SB (Table 1) and recommend a primarily conservative treatment approach. The level of evidence of the referred papers did not exceed level 1b. The final best-evidence treatment algorithm is shown in Fig. 1.

Diagnostics

The studies available for cutoff value determination were almost all retrospective with a small sample size, overall not exceeding LoE 1b. A comparison with arthrocentesis might help to verify these cutoff values. In arthrocentesis, WCCs greater than 2,000 cells/µl are considered inflammatory [63, 77], with a reported sensitivity of 0.84 and specificity of 0.84 [63], and WCCs greater than 50,000 cells/µl indicate septic arthritis [63, 75, 77]. A decrease of glucose to 20–30 mg/dl [26, 75] or PMN ratio

greater than 50 % [23, 77] is highly indicative of septic arthritis. Those figures are in line with the cutoff values defined for SB in the present study. Gram stain and culture are both diagnostic for septic arthritis. In contrast to a negative culture, a negative Gram stain does not preclude SB/arthritis. Positive bursal fluid cultures were reported in more than 90 % of septic bursitis cases [25, 59, 72], with even better results for liquid media [22, 72]. A recent study on severe SB reported only 67 % positive bursal fluid cultures [43], with a majority of negative aspirate cultures having received antibiotics prior to aspiration. In those cases, SB was defined as a combination of the typical clinical presentation, exclusion of other causes, and adequate response to antibiotics. This not only underlines the necessity of a bursal fluid aspiration prior to an antibiotic treatment but also stresses the importance of a detailed patient history and the need for a combination of various, differently weighted parameters for the diagnosis of SB.

Bursal fluid can be examined with a polarizing light microscope for the presence of cholesterol, monosodium urate, and calcium pyrophosphate dihydrate crystals. Positive findings indicate rheumatoid chylous bursitis, gout, and pseudogout, respectively [44, 70, 80, 83]. Since crystals and infections can occur simultaneously, and no data on the coincidence of both entities could be found, crystals were not included in the final decision.

Although further frequently assessed parameters for the classification of acute joint disorders were synovial LDH, pH, and lactate levels [22, 75, 77], no sufficient data could be found for bursitis. Further studies on bursal aspirate should consider evaluating the value of those parameters for bursitis.

Medical imaging, such as radiography, ultrasound, or MRI, has limited significance in the diagnosis of bursitis. Recent studies on the diagnostic value of ultrasound and MRI found both methods incapable of differentiating between NSB and SB [5, 19, 21]. These diagnostics sometimes might be requested in the case of suspected tendinosis, crystals, or osteomyelitis.

Treatment

The principle treatment algorithm consists of a surgical and conservative treatment arm, with the latter being the aspired one. Conservative treatment consists of bursal aspiration, PRICE, and NSAIDs. A further treatment option for NSB is intrabursal steroid injection, which has been discussed controversially in the literature [37, 46, 48, 67, 80]. Smith et al. [67] conducted a randomized controlled trial (LoE 1b) and found a more rapid decrease in swelling and fewer reaspirations with an intrabursal injection of methylprednisolone acetate compared to oral naproxen or placebo. This result has been confirmed by further studies [67, 70, 80]. Although Smith et al. [67] reported no complications within a six-month follow-up, other authors reported complications such as skin atrophy, chronic local pain, or local infection [46, 70, 80]. Because of to the high level of evidence, we considered intrabursal steroid injection an optional treatment in cases of failed conservative treatment or for patients requiring especially rapid convalescence, such as athletes and patients with high occupational demands [46].

Antibiotic therapy is the key element in SB treatment and should be started if an infection is suspected [13, 27, 43, 46, 50, 62, 70, 71, 83]. In most cases, oral antibiotics are sufficient, as they have been shown to achieve high intrabursal antibiotic levels [30]. In cases of severe SB requiring i.v. antibiotics, gentamicin can be added to the initial treatment. With this treatment protocol, Martinez-Taboada et al. [43] reported complete resolution in 99 % of severe SB cases.

Surgical therapy is indicated in critically ill or immunocompromised patients, patients with refractory or recurrent cases of bursitis, or if complications, such as skin necrosis, fistulas, pointing abscesses, or phlegmon of the surrounding soft tissue, occur [1]. Throughout the literature, the terms chronic, refractory, and recurrent are not clearly defined. Bursectomy can be performed open or endoscopically. Although few studies have recommended endoscopic bursectomy in septic bursitis [35, 50], several authors favor endoscopic bursectomy in cases of non-septic therapy refractory or chronic traumatic bursitis [34, 37, 38, 50, 51, 61, 69]. Endoscopic bursectomy has been shown to have a faster recovery, significantly lower morbidity, and better cosmetic results compared to open bursectomy [34, 37, 50, 51]. Open bursectomy should be chosen for critically ill or immunocompromised patients as well as severe soft tissue complications. A percutaneous suction-irrigation system has been mentioned by a few authors [39, 82, 83].

A comprehensive summary of outcome data is presented in Table 3. A primary conservative treatment approach is reinforced by comparing conservative treatment failure rates of 0–14 % [11, 27, 30, 40, 43, 56, 68, 71, 81] to 20 % recurrence rates following bursectomy, along with further relevant complications [8, 14, 15, 17, 24, 34, 37, 50, 51, 55–58, 69].

Limitations

In addition to the limitations discussed above, the major limitation of the developed treatment algorithm is the overall low level of evidence, most often Level 2b, as well as the small number of patients treated (ranging from $n = 6$ to $n = 343$ [38, 55]). Nevertheless, 55 studies were included in the final analysis, and their principal approach

was rather consistent and consisted of bursal aspiration and initial differentiation into non-septic and septic. As stated above, initial classification into NSB/SB is the key in this treatment algorithm. Even though the herein developed criteria for initial differentiation are based on studies of limited quality, these criteria compare favorably to the cutoff values defined for arthrocentesis.

Conclusions

The best-evidence treatment algorithm for prepatellar and olecranon bursitides presented here is based on a systematic review. Although the overall level of evidence available is limited, the criteria developed for initial classification into NSB and SB compare favorably to values obtained for arthrocentesis. The data available support a conservative approach, including repetitive bursal aspiration. This treatment algorithm needs to be validated and should therefore serve as a treatment guideline for future studies.

Conflict of interest The authors declare that they have no conflict of interest.

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