ical guidelines set forth by the American Society of Health-System Pharmacists (ASHP), the Infectious Diseases Society of America (IDSA), the Surgical Infection Society (SIS), the Society for Healthcare Epidemiology of America (SHEA) and the North American Spine Society support the use of first-generation cephalosporins [1,7,8]. Although comparative studies to evaluate the optimal timing for preoperative antibiotic have not been conducted for spine surgery, it is well-established that intravenous cephalosporins given within 60 minutes before initial incision is effective [9,10].

In a comparative study evaluating the addition of vancomycin powder for posterior thoracic and lumbar spine surgery, Sweet et al. found that vancomycin powder reduced the rate of SSI compared to intravenous cephalexin alone (0.2% vs. 2.6%, $p < 0.0001$).

Regarding prophylaxis regiments combining antibiotic agents, randomized clinical trials exist which show a reduced rate of postsurgical infections if a combination of a cephalosporin and gentamicin or vancomycin and gentamicin is used, compared to placebo [11,12]. However, there are no studies available which compare combination regimens with the standard prophylaxis with cefazolin. A study by Pons et al. comparing ceftizoxime versus the combination prophylaxis with vancomycin and gentamicin found no decreased infection rate, but higher toxicity with the combination regimen [13].

There is no specific recommendation for adapted prophylaxis in obese patients in spine surgery. However, in periprosthetic joint infections, adaptation is discussed in patients with a weight more than 100 kg since infection rate was twice that in other patients [13–15].

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Author: Dolors Rodriguez-Pardo

QUESTION 6: What are the optimal prophylactic antibiotics for patients with neurogenic bladder who are undergoing spine surgery?

RECOMMENDATION: The recommended standard perioperative antibiotic prophylaxis in spine surgery is cefazolin, but a broader-spectrum prophylaxis may be necessary in patient subpopulations more prone to acquiring surgical site infections (SSIs). In the case of neurogenic bladder, preoperative urine culture and individualized antibiotic prophylaxis are associated with a significant decrease in SSIs due to gram-negative bacilli (GNB).

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 79%, Disagree: 14%, Abstain: 7% (Super Majority, Strong Consensus)

RATIONALE

Prevention of SSI is of utmost importance in patients undergoing spine surgery, and perioperative antibiotic prophylaxis is a key measure to avoid this complication [1,2]. However, the superiority of one agent or schedule over any other has not been clearly demonstrated [1,2]. The recommended standard perioperative antibiotic prophylaxis in spinal surgery is cefazolin [1]. Isolated reports have shown that a broader-spectrum prophylaxis may be necessary in patient subpopulations more prone to acquiring poly-microbial SSI, such as those with neuromuscular deformities or spinal cord injury. In a retrospective observation study, Dessy et al. demonstrated that an enhanced antibiotic prophylaxis using intravenous (IV) cefuroxime for 24 hours plus vancomycin until drain removal in instrumented spinal surgery, and IV cefuroxime for 24 hours in non-instrumentation cases reduced the rate of SSIs in spine surgery [3].

There are no published data regarding the best antibiotic treatment to be used as prophylaxis in patients with neurogenic bladder. The North American Spine Society (NASS) evidence-based guidelines on antibiotic prophylaxis in spinal surgery have pointed out that potential subgroups of patients requiring effective prophylaxis against GNB may exist, although they have not been clearly defined [1]. In the case of patients with neurogenic bladder, they are more prone to urinary tract colorization and infection [4–5]. Although

asymptomatic bacteriuria (AB) should not be routinely treated in these patients because of rising resistance patterns, in the case of symptomatic urinary tract infection (UTI) antibiotic treatment should be administered and antibiotic selection should be based on local and patient-based resistance patterns so that the spectrum can be as narrow as possible [5]. In this line, recent Clinical Guidelines for the Diagnosis and Treatment of UTI of the Spanish Society of Infectious Diseases state that screening for, and treatment of, AB prior to performing instrumental spinal surgery is recommended for patients with neurogenic bladders or urinary incontinence in order to reduce the risk of gram-negative SSIs [6].

It was reported that up to 61% of children with myelomeningocele have neurogenic bladders [7–9]. Hatlen et al. demonstrated that the presence of positive urinary cultures before elective spine surgery for children with myelomeningocele leads to an increased risk of perioperative spine infections [10]. Olsen et al. conducted a case-control study to determine independent risk factors for SSI following orthopaedic spinal operations [11]. Among the patient-level factors in the univariate analysis, any incontinence (bowel or bladder, or both and preoperative or postoperative) significantly increased the risk of SSIs.

Although gram-positive organisms (particularly *Staphylococcus aureus*) predominate as causative agents for SSIs in patients undergoing spine surgery, GNB accounted for a sizeable portion of SSIs, particularly among lower lumbar and sacral spine surgical procedures [2]. Patients with incontinence, neurogenic bladder or indwelling catheters are more prone to urinary tract colonization and infection and may therefore be at higher risk of SSIs by GNB [4]. Contamination by GNB should not occur during the operative procedure, as these microorganisms are not usually present among the patient's skin flora [12]. Previous studies have suggested that GNB contamination could be secondary to hematogenous seeding originating in the urinary tract or to local skin contamination in incontinent patients, especially those undergoing surgery at the lumbosacral level [12].

Nuñez-Pereira et al. hypothesized that detecting urinary tract colonization preoperatively and adjusting antibiotic prophylaxis according to urine culture results might lower the overall SSI rate by reducing the number of GNB infections [12]. They performed a retrospective cohort study comparing two consecutive groups of patients undergoing posterior spinal fusion and instrumentation at a single institution. Cohort A included 236 patients, operated on between January 2006 and March 2007, receiving standard preoperative antibiotic prophylaxis with cefazolin (clindamycin in allergic patients). Cohort B included 223 patients operated on between January and December 2009, receiving individualized antibiotic prophylaxis and treatment based on preoperative urine culture. The study demonstrated that preoperative urine culture and individualized antibiotic prophylaxis are associated with a significant decrease in SSI due to GNB in high-risk patients undergoing spinal surgery.

Measures aimed at preventing UTI in patients with neurogenic bladder such as closed catheter drainage in patients with an indwelling catheter and the use of clean intermittent catheterization could reduce the risk of perioperative spine infections [4]. Intravesical Botox, bacterial interference and sacral neuromodulation show significant promise for the prevention of UTIs in neurogenic bladder patients [5].

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1.3. PREVENTION: BONE GRAFT

Author: Dolors Rodriguez-Pardo

QUESTION 1: Does the use of allograft increase the risk of spinal infection?

RECOMMENDATION: The use of allograft seems to increase the risk for infection in pediatric and neuromuscular scoliosis, however there is no increased risk in the adult degenerative population.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 77%, Disagree 0%, Abstain: 23% (Super Majority, Strong Consensus)