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QUESTION 2: What is the optimal irrigation solution (i.e., type, volume, frequency) to be used during clean elective orthopaedic procedures?

RECOMMENDATION: There is ample evidence to support the World Health Organization's (WHO) and Centers for Disease Control and Prevention's (CDC) recommendations that advocate the use of dilute betadine for the irrigation of wounds during surgical procedures. The optimal volume of irrigation solution is not known.

LEVEL OF EVIDENCE: Strong

DELEGATE VOTE: Agree: 75%, Disagree: 16%, Abstain: 9% (Super Majority, Strong Consensus)

RATIONALE

Intraoperative irrigation during clean elective orthopaedic procedures is one aspect of the operative protocol to reduce surgical site infections (SSIs), and there is general consensus that this technique in some form should be performed. Recently released guidelines by the CDC and WHO recommend intraoperative irrigation with dilute betadine prior to closure [1,2]. Betadine contains aqueous iodophor in the form of povidone-iodine which becomes chemically toxic to microorganisms when released as free iodine [3,4].

Povidone-iodine irrigation initially garnered support from studies in other fields, such as general, urologic, cardiovascular and spine surgeries [5–14]. A meta-analysis of seven randomized control trials demonstrated a statistically significant benefit for incisional wound irrigation with aqueous betadine, compared to normal saline solution (odds ratio (OR): 0.31, p = 0.007) [2]. In a larger meta-analysis of 15 level I or II studies in various surgical fields, 10 studies demonstrated that povidone-iodine irrigation was more effective than the control method that included irrigation with saline, water or no irrigation [15].

Although well-studied in other specialties, only one retrospective cohort study addresses intraoperative betadine irrigation in primary joint arthroplasty [16]. Brown et al. demonstrated a statistically significant reduction in SSI from 0.97 to 0.15% with the use of 0.35% povidone-iodine. Kokavec et al. studied betadine irrigation in a pediatric population undergoing surgery on the proximal femur, hip and pelvis [7]. In this study, two superficial wound infections were identified in the non-betadine group (2/73, 2.7%) and no infections were identified in the betadine group (0/89, 0%). (Table 1).

TABLE 1. Summary of orthopaedic literature comparing the efficacy of irrigation solutions with respect to prevention of SSI

Author	Category	N	Intervention	Comparison	Study Design	Analysis	Outcome	Incidence of SSI	P Value
Brown	TJA	2,550 (1,862 pre/ 688 post)	Betadine	Saline	Retrospective, pre-post	Univariate	D	0.15% vs. 0.97%	0.04
Cheng	Spine	414 (206 Ccrl/208 intervention)	Betadine	Saline	RCT	Multivariate	S & D	0% vs. 3.4%	0.01
Chang	Spine	244 (124 ctrl/120 intervention)	Betadine	Saline	RCT	Univariate	S & D	0% vs. 4.8%	0.03
Kokavec	Ortho	162 (73 ctrl/89 intervention)	Betadine	Saline	RCT	NA	S	0% vs. 2.7%	NA
Frisch	THA	391 (253 pre/ 138 post)	Chlorhexidine	Betadine	Retrospective, pre-post	Multivariate	S & D	(S) 0% vs. 1.2%	0.56
								(D) 0.8%	0.30

								vs. 1.6%	
Frisch	TKA	659 (411 pre/ 138 post)	Chlorhexidine	Saline	Retrospective; pre-post	Multivariate	S & D	(S) 0.8% vs. 0.7%	0.91
								(D) 1.2% vs. 0.7%	0.53

S, superficial infections; D, deep infections

In addition to isotonic saline and ringers lactate, several solutions such as antiseptics and antibiotic solutions have also been proposed as potential irrigation fluids in orthopaedic surgery. However, there is no consensus on a gold standard because of lack of clinical studies on the topic. Chlorhexidine is an antiseptic that alters the osmotic equilibrium of bacterial cells by binding to negatively charged molecules on the cell wall [17,18]. Chlorhexidine has a broad spectrum of activity [19] and can be bacteriostatic or bactericidal depending on its concentration [20]. Frisch et al. compared 0.05% chlorhexidine to normal saline irrigation in total knee arthroplasty (TKA) and 0.05% chlorhexidine to < 2% dilute betadine in total hip arthroplasty (THA) [21]. There was no significant difference in the rate of superficial or deep SSI between groups, which suggest that chlorhexidine may be comparable to normal saline in reducing infection rates.

While there is some evidence for the optimal irrigation solution, few studies have demonstrated an optimal volume or method for performing irrigation [22,23]. Additionally, there is little support for the benefits of adding antibiotics to irrigation solution, which was shown to be ineffective on metal surfaces in vitro, and thus this practice is not currently recommended by the WHO [22,24]. However, a single surgeon has reported beneficial results when vancomycin and polymyxin was added to irrigation solution in 2,293 TJAs [25].

Overwhelming evidence from published randomized control trials (RCTs) on the use of irrigation solutions for clean, elective orthopaedic procedures or surgeries suggest that both normal isotonic saline and ringers lactate solutions are safe and effective irrigation fluids. However, the majority of these studies were based on shoulder arthroscopic surgery [26–32], with limited studies on TKAs [31,33,34]. Whether ringers lactate is better than normal saline or vice versa is not known. However, in a laboratory-based study on surgically resected menisci from patients who underwent arthroscopic knee surgery, investigators aimed to determine whether there was a difference in the effect on cell morphology and function between isotonic saline and ringers lactate solutions. The findings showed that ringers lactate maintained better meniscal cell integrity compared with isotonic saline [35].

Emerging and consistent evidence suggests that warming of irrigation fluids (whether normal isotonic saline or ringers lactate) to temperatures of 32 to 40°C compared with room temperature irrigation fluids, decrease the risk of perioperative hypothermia and reduces inflammatory response in patients undergoing shoulder, hip or knee arthroscopy [28,31,36–38]. Only two RCTs have, to our knowledge, reported that warmed irrigation fluids were not superior to room temperature fluids in reducing the occurrence of perioperative hypothermia [30,39].

Results from three RCTs provided evidence that the addition of epinephrine to irrigation fluids improved the clarity of the visual field of surgery, reduced intraoperative bleeding and reduced total operating time compared with plain irrigation fluids [27,29,32]. The benefits of using chilled irrigation solutions in orthopaedic procedures was uncertain until recently. Li and colleagues performed an RCT and compared the effects of continuous irrigation of 4,000 mL cold saline plus 0.5% epinephrine vs. 4,000 mL normal saline at room temperature in patients undergoing TKAs [33]. Irrigation with cold saline was demonstrated to be associated with decreased postoperative pain, reduced intraoperative blood loss and improved quality of life.

Though commonly-used isotonic solutions such as normal saline or ringers lactate have been reported to be safe for joint irrigation in orthopaedic procedures, rare adverse events from excessive fluid irrigation have been documented. It has been reported that hyperosmolar solutions may have the potential to minimize these problems. However, their benefits have only so far been demonstrated in animal models. In a recent RCT, hyperosmolar irrigation was shown to decrease periarticular fluid retention in shoulder arthroscopy compared with standard of care irrigation fluid [26].

The role of continuous irrigation or pulse lavage in orthopaedic surgery has progressed from open fractures and contaminated wounds to being used in clean elective procedures. Furthermore, the optimum volume of irrigation solution used during orthopaedic procedures varies from one surgery to another. In studies of patients undergoing shoulder arthroscopy, average volume of fluid used for irrigation ranged from 3.7 to 11.4 L, and this was based on continuous irrigation with a pressure-control pump maintained at pressure settings of 30 to 60 mmHg [26–32].

For hip arthroscopy, evidence was based on an observational prospective study [38]. Median volume of irrigation solution was 27 L using an infusion pump with pressure between 45 and 65 mmHg. In the RCT by Kelly et al. investigating patients undergoing knee arthroscopy, the average volume of irrigation fluid used was 11.7 L [39]. In two studies of TKA (one RCT and one case series), continuous irrigation with 4 L of normal saline solution was used during surgery in each study [33,34]. In an RCT of hip hemiarthroplasty, 2 L of normal saline administered by pulse lavage was associated with a 30-day lower infection rate compared to 2 L normal saline washout by jug or syringe [10]. No data was reported on the pressure settings of the infusion pump in these studies.

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