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QUESTION 2: Does operative time affect the risks of surgical site infections/periprosthetic joint infections (SSIs/PJIs)?

RECOMMENDATION: Yes. There is an association between prolonged operative times and SSIs. Prolonged operative times may be a result of a considerable and inescapable level of complexity of the surgery. Coordinated efforts to reduce the operative times without technically compromising the procedure can provide additional benefits for infection prevention.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 99%, Disagree: 0%, Abstain: 1% (Unanimous, Strongest Consensus)

RATIONALE

Several systematic reviews and meta-analyses have demonstrated an association between operative times and SSIs as well as PJIs. Urquhart et al. [1] published a systematic review on risk factors for SSIs after primary total hip arthroplasty (THA), and found longer durations of surgery to be an independent risk factor for deep SSIs based on two studies [2,3], one of which was not specific to joint arthroplasty surgery. Kong et al. published a meta-analysis and found operative times to be associated with SSIs following primary THAs or total knee arthroplasties (TKAs) (standardized mean difference: 0.49, 95% confidence interval (CI) 0.19 to 0.78) [4]. Cheng et al. performed a meta-analysis over a variety of surgical procedures including orthopaedic surgery [5]. Pooled analysis demonstrated that the associations between extended operative times and SSIs typically remained statistically significant, with close to twice the likelihood of SSIs observed across various time thresholds [5]. The likelihood of SSIs increased with increasing time increments. For example, a 13%, 17% and 37% increased likelihood for every 15, 30 and 60 minutes of surgery, respectively [5]. On average, across various procedures, the mean operative time was approximately 30 minutes longer in patients with SSI compared to those patients without [5].

Administrative and registry databases have also linked increased operative times to SSIs/PJIs with statistical significances. Investigating 99,444 patients using the National Surgical Quality Improvement Program (NSQIP) database between 2011 and 2013, Duchman et al. found SSI was increased for primary total joint arthroplasty (TJA) procedures lasting > 120 minutes [6]. In their multivariate analysis, operative times exceeding 120 minutes remained an independent predictor for any complication and for wound complication, with each 30-minute increase in operative times beyond 120 minutes further increasing risks [6]. In an analysis of 56,216 primary TKAs from a registry collecting data from 45 locations in 6 US geographical regions, Namba et al. identified a 9% (95% CI 4 to 13%) increase in the risk of deep SSI per 15-minute incremental increase in operative time [7]. Decreased operative times were also associated with a lower risks of infections [7]. A study of 66,650 primary total hip arthroplasties reported to the Norwegian Arthroplasty Register during 1987 to 2001, revealed that cemented implants with operating time over 150 minutes were associated with an increased risk of revision due to infection [8]. Kurtz et al. investigated 69,663 patients over the age of 65 years undergoing TKAs from a Medicare claims database between 1997 and 2006, and found that longer duration procedures were at greater risk of PJI (adjusted hazard ratio for > 210 minutes vs. < 120 minutes = 1.59) [9]. In a multivariate analysis of 6,848 cases from 26 hospitals participating in the Korean Nosocomial Infections Surveillance System, Song et al. found that prolonged duration of surgery (above the 75th percentile) was an independent risk factor for SSIs in THA, but not for TKA [10]. Dicks et al. found patients undergoing TKAs or THAs that had an operative duration > 75th percentile had a higher risk of SSI [11]. Additionally, Peersman et al. found that an operating time of more than 2.5 hours for TKA was associated with an increased incidence of infection and that operating time can predict those patients at risk [12].

There are inherent limitations to database studies, such as significant heterogeneity of the samples, differences in data collection, and varying definitions of PJIs within the sample. Single institutional work is therefore useful in this context because patients are subjected to the same care protocols, and more reliable data collection may be obtained. However, high-quality institutional studies have been limited by a lack of adequate sample size, absence of multivariate analysis and varying definitions of PJI. Peersman et al. compared a cohort of 113 PJIs following TKA with a control cohort of non-infected primary TKA matched for gender and age [13]. The mean duration of surgery for PJI vs. non-infected cases (127 vs. 93 minutes) was found to be a statistically significant risk factor for infections. Limitations of this study were that the control group was only matched for age and gender, but not for other important confounding factors. Additionally, the infection group included both index primary and revision cases, while the control group only included primary cases. In another single institutional study of 5,277 TJA, overall infection rate was 0.98% (51/5,277) [14]. Using a binomial generalized linear model, prolonged operative time was found to be associated with an increased incidence of infection ($z = 4.325$, $p < 0.001$). In TKA, a longer tourniquet time ($z = 2.867$, $p = 0.004$) was predictive of SSIs as well [14]. Again, the major limitation of this study was that it did not include confounding factors such as diabetes mellitus, rheumatoid arthritis or obesity. In a retrospective review by Wang et al. [15], 17,342 unilateral primary TKA and THA performed by 7 high volume surgeons, patients with an operative time of > 90 minutes were found to have higher incidence of SSIs and PJIs (2.1 and 1.4%,) compared to cases lasting 60 to 90 minutes (1.1 and 0.7%), and those lasting ≤ 60 minutes (0.9 and 0.7%). This trend was statistically significant ($p < 0.01$). After controlling for multiple confounding factors with multivariate regression, prolonged operative times remained an independent risk factor for 90-day SSI (odds ratio (OR): 1.01, 95% CI 1.002 to 1.016, $p = 0.009$) and PJI within 1 year (OR: 1.01, 95% CI 1.00 to1.02, $p = 0.040$) [15].

In contrast, some studies have failed to demonstrate such a correlation, especially when aiming to control for confounding variables. In a retrospective review of 9,245 TJA patients (4,185 TKAs and 5,060 THAs), longer operative times were a predisposing factor for PJI with univariate analysis, but multivariate analysis that adjusted for confounding factors revealed that operative time was not an independent predisposing factor for PJI [16]. Similarly, Naranje et al. found that after controlling for age and sex, there was no significant evidence that increased operative time increased the hazard of revision resulting from infection [17]. However, they did show a 15-minute increase in operative time increased the hazard of revision for infection by 15.6% on average ($p = 0.053$; 95% CI 0.0% to 34.1%) [17]. Saleh et al. retrospectively reviewed 1,181 TKA and 1,124 THA primary procedures. Of the factors examined, only hematoma formation and days of postoperative drainage were significant predictors of SSI or deep wound infection, and operative time was not a significant risk factor [18]. Carroll et al. conducted a retrospective cohort study of 964 patients undergoing THA and TKA in one institute over 18 months.

Although tourniquet times were found to be an independent risk factor for superficial wound complication (defined by either a superficial incisional SSI or prolonged wound ooze within 30 days of surgery) in the TKA cohort, operative times were not an independent risk factor in their analysis [19]. Lastly, Kremers et al. found no significant relationship between SSIs and operative times (per 10-minute intervals) [20].

There is considerable evidence that suggests an association between prolonged operative times and SSIs/PJIs with a few studies suggesting no correlation. Steps to minimize intraoperative delay should be taken, and care should be exercised when introducing measures which prolong the duration of joint arthroplasty surgery.

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