sterile objects, such as the OR lights, should be kept as far away from the surgical field and sterile equipment as practically possible. It is plausible that contaminated particles may fall into the surgical field during orthopaedic procedures, if such scenario arises, we recommend that copious irrigation of the operative field with the use of normal saline and antiseptic solutions, such as dilute betadine, be performed.

Further basic science (simulation-based) and implementation research in this area is warranted.

REFERENCES

[1] Nogler M, Lass-Flörl C, Ogon M, Mayr E, Bach C, Wimmer C. Environmental and body contamination through aerosols produced by high-speed cutters in lumbar spine surgery. Spine. 2001;26:2156–219.

[2] Nogler M, Lass-Flörl C, Wimmer C, Bach C, Kaufmann C, Ogon M. Aerosols produced by high-speed cutters in cervical spine surgery: extent of environmental contamination. Eur Spine J. 2001;10:274–277. doi:10.1007/s005860100310.

[3] Nogler M, Wimmer C, Lass-Flörl C, Mayr E, Trobos S, Gegenhuber C. Contamination risk of the surgical team through ROBODOC's high-speed cutter. Clin Orthop Relat Res. 2001:225–231.

[4] Nogler M, Lass-Flörl C, Wimmer C, Mayr E, Bach C, Ogon M. Contamination during removal of cement in revision hip arthroplasty. A cadaver study using ultrasound and high-speed cutters. J Bone Joint Surg Br. 2003;85:436–439.

[5] Gardiner R, Hozack WJ, Nelson C, Keating EM. Revision total hip arthroplasty using ultrasonically driven tools. A clinical evaluation. J Arthroplasty. 1993;8:517–521.

[6] Lidwell OM, Lowbury EJ, Whyte W, Blowers R, Stanley SJ, Lowe D. Airborne contamination of wounds in joint replacement operations: the relationship to sepsis rates. J Hosp Infect. 1983;4:111–131.

[7] Whyte W, Hodgson R, Tinkler J. The importance of airborne bacterial contamination of wounds. J Hosp Infect. 1982;3:123–135.

[8] Howorth FH. Prevention of airborne infection during surgery. Lancet 1985;1:386–388.

[9] Stocks GW, Self SD, Thompson B, Adame XA, O'Connor DP. Predicting bacterial populations based on airborne particulates: a study performed in nonlaminar flow operating rooms during joint arthroplasty surgery. Am J Infect Control. 2010;38:199–204. doi:10.1016/j.ajic.2009.07.006.

[10] Ritter MA, Eitzen H, French ML, Hart JB. The operating room environment as affected by people and the surgical face mask. Clin Orthop Relat Res. 1975:147–150.

[11] Quraishi ZA, Blais FX, Sottile WS, Adler LM. Movement of personnel and wound contamination. AORN J. 1983;38:146–147, 150–156.

[12] Panahi P, Stroh M, Casper DS, Parvizi J, Austin MS. Operating room traffic is a major concern during total joint arthroplasty. Clin Orthop Relat Res. 2012;470:2690–2694. doi:10.1007/s11999-012-2252-4.

[13] Baird RA, Nickel FR, Thrupp LD, Rucker S, Hawkins B. Splash basin contamination in orthopaedic surgery. Clin Orthop Relat Res. 1984:129–133.

[14] Anto B, McCabe J, Kelly S, Morris S, Rynn L, Corbett-Feeney G. Splash basin bacterial contamination during elective arthroplasty. J Infect. 2006;52:231–232. doi:10.1016/j.jinf.2005.06.013.

[15] Berbari E, Segreti J, Parvizi J, Berríos-Torres SI. Future research opportunities in peri-prosthetic joint infection prevention. Surg Infect (Larchmt). 2017;18:409–412. doi:10.1089/sur.2017.065.

1.6. PREVENTION: SURGICAL TECHNIQUE

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QUESTION 1: Does the use of a tourniquet influence the rates of surgical site infections/periprosthetic joint infections (SSIs/PJIs) in primary or revision total knee arthroplasty (TKA)?

RECOMMENDATION: The literature is inconclusive regarding the use of a tourniquet during TKA and its potential to increase the risks for SSIs/PJIs in TKAs. Tourniquet times and pressures should be minimized to reduce this risk.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 89%, Disagree: 9%, Abstain: 2% (Super Majority, Strong Consensus)

RATIONALE

The use of a pneumatic tourniquet during TKA has long been a standard for this procedure. However, concerns have arisen over the ischemic injury that can occur from tourniquet use. This has prompted many authors to conduct studies evaluating the use and non-use of a tourniquet and its effect on perioperative blood loss, postoperative pain and function and postoperative complications [1–7]. However, many of these studies are small, randomized controlled trials (RCTs) that lack the power to definitively state the influence om tourniquet use of SSIs and PJIs.

Liu et al. showed in a RCT of 52 patients undergoing simultaneous bilateral TKA that tourniquet use was associated with greater wound ooze and blistering, as well as the only deep infection in the cohort occurring in a TKA case that had been performed while using a tourniquet [8]. In a 31-patient RCT, Clarke et al. demonstrated that increased tourniquet pressures led to sustained wound hypoxia up to one week following surgery [9]. A meta-analysis by Yi et al. evaluated 13 RCTs of tourniquet use comprising 859 patients. Of these 13 studies, 3 evaluated infection risk, SSI and PJI together, and they found that tourniquet use was significantly associated with an increased risk of infection [6]. A meta-analysis by Zhang et al. found a similar pooled result with tourniquet use associated with a greater risk of non-thrombotic complications, infection included [10].

Longer tourniquet times, and by virtue longer surgical times, have been associated with an increased risk for both SSI and PJI [11–13]. Willis-Owen et al. in a series of 3,449 consecutive TKAs found that patients who went on to have a SSI/PJI had significantly longer tourniquet times than noninfected patients [11]. Ricciardi et al. found a similar result in their analysis of perioperative variables affecting 30-day readmission [12]. Na et al. evaluated early release of the tourniquet following cementation of components versus reinflation of the tourniquet after controlling bleeding in 206 patients and found that the increased tourniquet time for patients in the reinflation group did not affect the rate of wound complications, SSI or PJI [14]. However, none of these studies were able to propose a cutoff for tourniquet time over which the risk of SSI and PJI begins to increase. These studies also did not differentiate between operative time and tourniquet time. As increased surgical time is a known risk factor for

SSI and PJI, the confounding effect of increased surgical time may be influencing the relationship between tourniquet time and postoperative infections.

There is still much debate over the efficacy of tourniquet use to decrease perioperative blood loss. Ledin et al. conducted a RCT on 50 consecutive TKAs on the use of a tourniquet and found no difference in calculated perioperative blood loss [15]. The meta-analysis by Zhang et al. found that calculated blood loss was greater without the use of a tourniquet, however this did not result in a greater transfusion requirement [10]. Conversely, a meta-analysis by Jiang et al. found that tourniquet use did decrease transfusion requirement in the pooled analysis of 1,450 knees [16]. As allogeneic blood transfusion is a known risk factor for SSI and PJI, limiting blood loss is an important aspect of infection prevention [17–20].

Another concern with the use of a tourniquet during TKA is whether appropriate antibiotic prophylaxis is administered to the surgical site. Friedman et al. evaluated soft tissue and bone concentrations of antibiotics given one minute, two minutes and five minutes prior to tourniquet inflation and found the highest concentrations to be when antibiotics were administered five minutes prior to inflation [21]. Yamada et al. found that when cefazolin was administered 15 minutes prior to inflation, the concentration in bone and soft tissue at the surgical site were above the minimum inhibitory concentration (MIC90) for methicillin sensitive *Staphylococcus aureus*, but below the MIC90 for cephazolin resistant coagulase negative staphylococcal species [22]. Young et al. found that by administering antibiotic prophylaxis intraosseously, higher regional antibiotic concentrations could be achieved, however the clinical efficacy of this in reducing the rates of SSI and PJI still need to be evaluated [23].

The effect that the use of a tourniquet has on the incidence of SSIs and PJIs following TKA has not been fully evaluated. The RCTs of this subject have been of small cohorts of patients that lack the power to evaluate these complications. The meta-analyses on this topic also have not been able to definitively comment, as many studies did not report the incidence of SSI and PJI in their cohorts. Moving forward, studies evaluating the use of a tourniquet during TKA should consider SSI and PJI as a secondary endpoint so that future pooled analyses may be better able to elucidate a connection, if one exists.

REFERENCES

[1] Alcelik, I, Pollock, RD, Sukeik, M, Bettany-Saltikov, J, Armstrong, PM, Fismer, P. A comparison of outcomes with and without a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. J Arthroplasty. 2012;27:331–340.

[2] Tie, K, Hu, D, Qi, Y, Wang, H, Chen, L: Effects of tourniquet release on total knee arthroplasty. Orthopedics. 2016;39:e642-e650.

[3] Olivecrona, C, Ponzer, S, Hamberg, P, Blomfeldt, R. Lower tourniquet cuff pressure reduces postoperative wound complications after total knee arthroplasty: a randomized controlled study of 164 patients. J Bone Joint Surg Am. 2012;94:2216–2221.

[4] Wang, K, Ni, S, Li, Z, Zhong, Q, Li, R, Li, H, Ke, Y, Lin, J. The effects of tourniquet use in total knee arthroplasty: a randomized, controlled trial. Knee Surg Sports Traumatol Arthrosc. 2017 Sep;25:2849-2857.

[5] Tai, TW, Lin, CJ, Jou, IM, Chang, CW, Lai, KA, Yang, CY. Tourniquet use in total knee arthroplasty: a meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2011;19:1121–1130.

[6] Yi, S, Tan, J, Chen, C, Chen, H, Huang, W. The use of pneumatic tourniquet in total knee arthroplasty: a meta-analysis. Arch Orthop Trauma Surg. 2014;134:1469–1476.

[7] Mutlu, S, Guler, O, Mutlu, H, Karaman, O, Duymus, TM, Parmaksizoglu, AS. Tourniquet use during total knee arthroplasty does not offer significant benefit: a retrospective cohort study. Int J Surg Lond Engl. 2015;18:123–127.

[8] Liu, PL, Li, DQ, Zhang, YK, Lu, QS, Ma, L, Bao, XZ, Zhang, M. Effects of unilateral tourniquet used in patients undergoing simultaneous bilateral total knee arthroplasty. Orthop Surg. 2017;9:180–185.

[9] Clarke, MT, Longstaff, L, Edwards, D, Rushton, N. Tourniquet-induced wound hypoxia after total knee replacement. J Bone Joint Surg Br. 2001;83:40–44.

[10] Zhang, W, Li, N, Chen, S, Tan, Y, Al-Aidaros, M, Chen, L. The effects of a tourniquet used in total knee arthroplasty: a meta-analysis. J Orthop Surg. 2014;9:13.

[11] Willis-Owen, CA, Konyves, A, Martin, DK. Factors affecting the incidence of infection in hip and knee replacement: an analysis of 5,277 cases. J Bone Joint Surg Br. 2010;92:1128–1133.

[12] Ricciardi, BF, Oi, KK, Daines, SB, Lee, YY, Joseph, AD, Westrich, GH. Patient and perioperative variables affecting 30-day readmission for surgical complications after hip and knee arthroplasties: a matched cohort study. J Arthroplasty. 2017;32:1074–1079.

[13] Butt, U, Ahmad, R, Aspros, D, Bannister, GC. Factors affecting wound ooze in total knee replacement. Ann R Coll Surg Engl. 2011;93:54–56.

[14] Na, YG, Bamne, AB, Won, HH, Kim, TK. After early release of tourniquet in total knee arthroplasty, should it be reinflated or kept deflated? A randomized trial. Knee Surg Sports Traumatol Arthrosc. 2017;25:2769–2777.

[15] Ledin, H, Aspenberg, P, Good, L. Tourniquet use in total knee replacement does not improve fixation, but appears to reduce final range of motion. Acta Orthop. 2012;83:499–503.

[16] Jiang, FZ, Zhong, HM, Hong, YC, Zhao, GF. Use of a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. J Orthop Sci Off J Jpn Orthop Assoc. 2015;20:110–123.

[17] Parvizi, J, Diaz-Ledezma, C. Total knee replacement with the use of a tourniquet: more pros than cons. Bone Jt J. 2013;95-B:133–134.

[18] Everhart, JS, Sojka, JH, Mayerson, JL, Glassman, AH, Scharschmidt, TJ. Perioperative allogeneic red blood-cell transfusion associated with surgical site infection after total hip and knee arthroplasty. J Bone Joint Surg Am. 2018;100:288–294.

[19] Kim, JL, Park, JH, Han, SB, Cho, IY, Jang, KM. Allogeneic blood transfusion is a significant risk factor for surgical-site infection following total hip and knee arthroplasty: a meta-analysis. J Arthroplasty. 2017;32:320–325.

[20] Friedman, R, Homering, M, Holberg, G, Berkowitz, SD. Allogeneic blood transfusions and postoperative infections after total hip or knee arthroplasty. J Bone Joint Surg Am. 2014;96:272–278.

[21] Friedman, RJ, Friedrich, LV, White, RL, Kays, MB, Brundage, DM, Graham, J. Antibiotic prophylaxis and tourniquet inflation in total knee arthroplasty. Clin Orthop Relat Res. 1990;17–23.

[22] Yamada K, Matsumoto K, Tokimura F, Okazaki H, Tanaka S. Are bone and serum cefazolin concentrations adequate for antimicrobial prophylaxis? Clin Orthop Relat Res. 2011;469:3486–3494.

[23] Young, SW, Zhang, M, Freeman, JT, Vince, KG, Coleman, B. Higher cefazolin concentrations with intraosseous regional prophylaxis in TKA. Clin Orthop Relat Res. 2013;471:244–249.

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QUESTION 2: Does the surgical approach (parapatellar vs. subvastus) during primary total knee arthroplasty (TKA) affect the incidence of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs)?

RECOMMENDATION: The incidence of SSIs/PJIs after primary TKA is not influenced by the surgical approach (parapatellar vs. subvastus).

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 97%, Disagree: 1%, Abstain: 2% (Unanimous, Strongest Consensus)