Authors: Benjamin Zmistowski, Joseph Zuckerman, Mandeep Virk

QUESTION 8: Does the sampling technique (e.g., number of samples, tissue versus fluid versus implant, anatomic locations) affect the results for culture of specimens obtained in the evaluation of shoulder periprosthetic joint infection (PJI)?

RECOMMENDATION: We recommend five deep tissue specimens for culture be obtained from various surgical sites (e.g., capsule, humeral canal and periprosthetic membranes in the proximal humerus and glenoid). Use of swabs is discouraged. Fresh instruments should be used to obtain and place samples directly into sterile containers. Fluid sampling may be beneficial but has lower yield compared to tissue.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

The shoulder presents a unique challenge in evaluating and treating PJI. The diagnosis of PJI is currently heavily reliant on culture results around the time of revision surgery. These culture results are frequently positive—often unexpectedly [1–4]—and the implications have yet to be fully elucidated [5–8]. To understand the most effective methods for obtaining samples for culture, a systematic review of the existing literature was undertaken. A Scopus [9] search was performed with the query, "(shoulder OR "upper extremity") AND (arthroplasty OR replacement OR revision) AND (culture OR microbiologic OR microbiology)." The resulting titles and abstracts (n = 218) from this query were reviewed for any pertinence to the question of number of samples for culture, specimen type and anatomic locations. All pertinent articles (n = 28) were then fully reviewed, and any other pertinent citations in these gathered articles were obtained and reviewed.

In cases concerning for possible shoulder PJI an attempt to make a preoperative case for surgical planning is desirable. Historically, preoperative joint aspiration and fluid culture has served in this endeavor. However, recent evidence has demonstrated a poor sensitivity of fluid cultures [6,10–12]. Three separate analyses out of a single institution repeatedly demonstrated decreased rates of positive cultures (27-38%) from fluid specimens compared to solid tissue (34-66.5%) and explants (46-55.6%) [6,10,11]. In a separate analysis, Dilisio et al. compared arthroscopic biopsy results (a minimum of three samples) and preoperative fluroscopically-guided aspiration for culture in patients who went on to open revision arthroplasty [12]. They found that arthroscopic biopsy had 100% concordance with culture at the time of open surgery; however, aspirated fluid had a sensitivity 16.7% and specificity of 100%. However, while these data suggest that fluid aspiration is not the optimal specimen type for culture, it is less invasive compared to arthroscopic biopsy.

Another potential source for culture is sampling of the explanted components. In separate analyses, Lucas et al. and Ahsan et al.demonstrated similar positive culture results from explant vortex samples and solid tissue cultures [6,10]. Lucas et al. also found that 56% (24/43) of loose glenoid components were culture-positive after vortex sampling compared to 13% (1/8) of stable glenoid components [6]. However, in 53 patients undergoing revision shoulder arthroplasty (25 infections), Grosso et al. found that cultures of fluid from explant sonication had a sensitivity and specificity of 56% and 93%, respectively, when using a threshold of 20 colony-forming-units (CFU) per milliliter (mL) [13]. When removing this threshold, the sensitivity improved to 96% but the specificity decreased to 64%. This was compared to 96% and 75% sensitivity and specificity, respectively, for solid tissue cultures. Unfortunately, this analysis excluded those patients that received preoperative antibiotics—a population that has historically benefited the most from explant sonication cultures [14]. In a separate analysis of 136 revision or resection shoulder arthroplasties, Piper et al. was unable to find a statistically-significant improvement in sensitivity of explant sonication (66.7%) compared to solid tissue cultures (54.5%) [15]. Despite this, the authors advocated for explant sonication. However, taking into account all of the existing literature specific to shoulder PJI, there is little support for routine use of explant culturing in revision shoulder arthroplasty.

When collecting solid tissue for culture, a common question is the optimum location and number of samples. Specifically in the shoulder, Pottinger et al. and Frangiamore et al. demonstrated a positive correlation between the number of samples taken and the number of positive culture results [4,16]. Pottinger et al. found an odds ratio for positive culture results of 1.24-1.35 per sample obtained [4]. Frangiamore, however, found no association between the number of samples obtained and the proportion of samples that were positive [16]. In an analysis of *C. acnes* in revision shoulder arthroplasty, Matsen et al. determined that, given their proportion of positive cultures, four specimens would provide a 95% chance of detecting the organism [11]. With the goal of increasing the sensitivity of tissue culture without additional costs of unnecessary cultures and sacrificing specificity, the appropriate number of samples can be a difficult target, aggravated by the current lack of a uniform definition of PJI specific to shoulder arthroplasty [17]. From the general arthroplasty literature, Atkins et al. reviewed 297 revision hip and knee arthroplasty cases with modeling to determine that five to six specimens provided the best sensitivity and specificity of PJI diagnosis with a target of two positive cultures [18]. In a more recent analysis, Peel et al. reviewed 499 patients undergoing arthroplasty (60 shoulders) using the Musculoskeletal Infection Society (MSIS) definition of PJI [19,20]. Using the results of their review, they performed mathematical modeling to determine that the optimal number of samples for standard tissue culture was four. Unfortunately, the use of the modified MSIS definition of PJI may confound the results of their analysis as applied to shoulder arthroplasty—known to be a more indolent presentation of infection. Given this current evidence, it is recommended that four to five samples be obtained during revision shoulder arthroplasty to minimize cost and likelihood of false-positive results while increasing culture sensitivity in revision shoulder arthroplasty.

In determining the best locations for specimen selection, it is first imperative to sample from any sites consistent with active infection through signs of inflammation, acute purulence or necrosis. In their analysis of the origin of *C. acnes* positive cultures in revision shoulder arthroplasty, Matsen et al. found that periprosthetic

membranes, especially the humeral membrane, had the highest rate of positive cultures for *C. acnes* [11]. For arthroscopic evaluation of PJI, Dilisio et al. biopsied at least three different sites with evidence of synovitis and prosthetic contact [12].

REFERENCES

[1] Falconer TM, Baba M, Kruse LM, Dorrestijn O, Donaldson MJ, Smith MM, et al. Contamination of the surgical field with Propionibacterium acnes in primary shoulder arthroplasty. J Bone Joint Surg Am. 2016;98:1722–1728. doi:10.2106/JBJS.15.01133.

[2] Foruria AM, Fox TJ, Sperling JW, Cofield RH. Clinical meaning of unexpected positive cultures (UPC) in revision shoulder arthroplasty. J Shoulder Elbow Surg. 2013;22:620–627. doi:10.1016/j.jse.2012.07.017.

[3] Koh CK, Marsh JP, Drinković D, Walker CG, Poon PC. Propionibacterium acnes in primary shoulder arthroplasty: rates of colonization, patient risk factors, and efficacy of perioperative prophylaxis. J Shoulder Elbow Surg. 2016;25:846–852. doi:10.1016/j.jse.2015.09.033.

[4] Pottinger P, Butler-Wu S, Neradilek MB, Merritt A, Bertelsen A, Jette JL, et al. Prognostic factors for bacterial cultures positive for Propionibacterium acnes and other organisms in a large series of revision shoulder arthroplasties performed for stiffness, pain, or loosening. J Bone Joint Surg Am. 2012;94:2075–2083. doi:10.2106/JBJS.K.00861.

[5] Kelly JD, Hobgood ER. Positive culture rate in revision shoulder arthroplasty. Clin Orthop Relat Res. 2009;467:2343–2348. doi:10.1007/s11999-009-0875-x.

[6] Lucas RM, Hsu JE, Whitney IJ, Wasserburger J, Matsen FA. Loose glenoid components in revision shoulder arthroplasty: is there an association with positive cultures? J Shoulder Elbow Surg. 2016;25:1371–1375. doi:10.1016/j.jse.2015.12.026.

[7] Padegimas EM, Lawrence C, Narzikul AC, Zmistowski BM, Abboud JA, Williams GR, et al. Future surgery after revision shoulder arthroplasty: the impact of unexpected positive cultures. J Shoulder Elbow Surg. 2017;26:975–981. doi:10.1016/j.jse.2016.10.023.

[8] Topolski MS, Chin PYK, Sperling JW, Cofield RH. Revision shoulder arthroplasty with positive intraoperative cultures: the value of preoperative studies and intraoperative histology. J Shoulder Elbow Surg. 2006;15:402–406. doi:10.1016/j.jse.2005.10.001.

[9] Scopus. Document details n.d. https://www-scopus-com.proxy1.lib.tju.edu/record/display.uri?eid=2-s2.0-00273003555&origin=inward&txGid=A7C2209533A7FC3E01AB869C3A68C558.wsnAw8kcdt7IPYLOoV48gA%3a1 (accessed June 21, 2017).

[10] Ahsan ZS, Somerson JS, Matsen FA. Characterizing the Propionibacterium load in revision shoulder arthroplasty: a study of 137 culture-positive cases. J Bone Joint Surg Am. 2017;99:150–154. doi:10.2106/JBJS.16.00422.

[11] Matsen FA, Butler-Wu S, Carofino BC, Jette JL, Bertelsen A, Bumgarner R. Origin of propionibacterium in surgical wounds and evidence-based approach for culturing propionibacterium from surgical sites. J Bone Joint Surg Am. 2013;95:e1811–e1817. doi:10.2106/JBJS.L.01733.

[12] Dilisio MF, Miller LR, Warner JJP, Higgins LD. Arthroscopic tissue culture for the evaluation of periprosthetic shoulder infection. J Bone Joint Surg Am. 2014;96:1952–1958. doi:10.2106/JBJS.M.01512.

[13] Grosso MJ, Frangiamore SJ, Yakubek G, Bauer TW, Iannotti JP, Ricchetti ET. Performance of implant sonication culture for the diagnosis of periprosthetic shoulder infection. J Shoulder Elbow Surg. 2018;27:211–216. doi:10.1016/j.jse.2017.08.008.

[14] Trampuz A, Piper KE, Hanssen AD, Osmon DR, Cockerill FR, Steckelberg JM, et al. Sonication of explanted prosthetic components in bags for diagnosis of prosthetic joint infection is associated with risk of contamination. J Clin Microbiol. 2006;44:628–631. doi:10.1128/JCM.44.2.628-631.2006.

[15] Piper KE, Jacobson MJ, Cofield RH, Sperling JW, Sanchez-Sotelo J, Osmon DR, et al. Microbiologic diagnosis of prosthetic shoulder infection by use of implant sonication. J Clin Microbiol. 2009;47:1878–1884. doi:10.1128/JCM.01686-08.

[16] Frangiamore SJ, Saleh A, Grosso MJ, Alolabi B, Bauer TW, Iannotti JP, et al. Early versus late culture growth of Propionibacterium acnes in revision shoulder arthroplasty. J Bone Joint Surg Am. 2015;97:1149–1158. doi:10.2106/JBJS.N.00881.

[17] Hsu JE, Somerson JS, Vo KV, Matsen FA. What is a "periprosthetic shoulder infection"? A systematic review of two decades of publications. Int Orthop. 2017;41:813–822. doi:10.1007/s00264-017-3421-6.

[18] Atkins BL, Athanasou N, Deeks JJ, Crook DW, Simpson H, Peto TE, et al. Prospective evaluation of criteria for microbiological diagnosis of prosthetic-joint infection at revision arthroplasty. The OSIRIS Collaborative Study Group. J Clin Microbiol. 1998;36:2932–2939.

[19] Peel TN, Spelman T, Dylla BL, Hughes JG, Greenwood-Quaintance KE, Cheng AC, et al. Optimal periprosthetic tissue specimen number for diagnosis of prosthetic joint infection. J Clin Microbiol. 2017;55:234–243. doi:10.1128/JCM.01914-16.

[20] Zmistowski B, Della Valle C, Bauer TW, Malizos KN, Alavi A, Bedair H, et al. Diagnosis of periprosthetic joint infection. J Orthop Res. 2014;32 Suppl 1:S98–S107. doi:10.1002/jor.22553.