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Review

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Chest complications in autologous breast reconstruction

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Abstract

Complications from autologous free flap reconstruction of the breast can present with both common surgical complications and unique complications at the chest recipient site. This review covers complications at the chest recipient site, including chest wall deformity, chronic pain, mastectomy skin flap necrosis, infection, pyoderma gangrenosum, bleeding complications, pneumothorax, chyle leak, and positive internal mammary lymph node metastasis.

Keywords: Autologous breast reconstruction, complications, chest wall deformity, pneumothorax, mastectomy skin flap necrosis, chyle leak, internal mammary node metastasis

INTRODUCTION

The deep inferior epigastric artery perforator (DIEP) flap remains the gold standard in autologous breast reconstruction. DIEP flap surgery poses many challenges and potential for complications, which can be related to the flap itself, the flap donor site, the chest recipient site, or systemic. This review will focus on complications of the chest from the internal mammary recipient vessel dissection, including chest wall deformity from rib resection and chronic pain, mastectomy skin flap necrosis, infection, pyoderma gangrenosum, bleeding complications, pneumothorax, chyle leak, and positive internal mammary lymph node metastasis. Each topic will explore current literature and recommendations based on clinical

experience.

CHEST WALL DEFORMITY AND PAIN ASSOCIATED WITH RIB RESECTION

Use of the internal mammary artery and vein as the flap recipient site traditionally includes the removal of rib cartilage for exposure of the vessels[1,2]. With excision of the rib cartilage, two main primary concerns include chronic pain and chest wall deformity[3-7]. Several techniques have been subsequently described to try to alleviate these issues, including rib-sparing[3,8-15], simultaneous rib-sparing[16], and anastomosis to intercostal perforator vessels[14,17,18] to avoid or minimize rib resection. Additionally, consideration can be given to the utilization of alternative recipient vessels, such as the thoracodorsal vessels. With removal of the rib cartilage, techniques to reduce the chest wall deformity include the use of a pectoralis flap[19,20], placement of the medial portion of the flap over the defect[5], and replacement of the cartilage[4].

First described in 2008 by Parrett, the rib-sparing technique involves resection of the intercostal muscles as well as the perichondrium on either side of the third intercostal space (ICS), allowing for 2 to 2.5 cm of internal mammary vessel pedicle length[3]. Rosich-Medina *et al.* reported results of 178 free flaps in 167 patients with no postoperative chest wall pain or concerns over chest wall contour after rib-sparing exposure of the internal mammary vessels[13]. Sacks *et al.* reported the results of 100 microvascular reconstructive cases using the rib-sparing technique with no noted contour deformities[12]. Mickute *et al.* looked at patient-controlled anesthesia (PCA) morphine use postoperatively in 12 rib-sparing versus 12 rib removal patients and found significantly less morphine use (mean 11.0 mg *vs.* 28.6 mg) in the rib-sparing group, which held true when accounting for patient weight[21].

Computed tomography (CT) has been used to measure intercostal spaces preoperatively, with the finding that increased patient height correlated to increased ICS width[8]. In the patients with preoperative CT scan, the mean ICS width was 2.65 ± 0.54 cm in rib-sparing patients compared to 2.25 ± 0.38 cm in a rib resection group[8]. Khoo *et al.* published results of intra-operative clinical measurement of the second ICS width performed with a surgical ruler in 95 patients/109 breasts, and found a mean of 2.03 ± 0.331 cm, and a very weak positive correlation with patient height[9]. Sasaki *et al.* found similar measurements of 2.06 ± 0.359 cm for the second ICS (290 evaluated) and 1.40 ± 0.420 cm for the third ICS (30 evaluated)[10]. A retrospective chart review of 400 patients performed by Hamilton *et al.* found conversion to or initial attempt with rib resection for patients when the ICS was less than 12 mm[11].

If ICS dissection does not provide adequate space for anastomosis, the ribs may be trimmed with a rongeur and the microscope can be tilted to visualize the vessels as they pass under the rib for continued dissection[8,10,12,14]. Darcy *et al.* described resection of the posterior portion of the cartilage to improve exposure while leaving the anterior surface intact 30% of the time after increased experience with this technique[14]. Another technique includes the exposure of two contiguous ICSs (second and third) without rib resection as described by Oni *et al.*[16]. This method provided for additional exposure of the internal mammary vessels in cases such as bipedicled flaps, stacked free flaps, anastomotic redo, and salvage. Successful completion of this technique provided for antegrade and retrograde anastomoses in 15 patients with no flap failure. They noted mean second ICS width of 2.07 cm and third ICS width of 1.20 cm[16].

Consideration should also be given to the ICS that is selected. One concern with rib-sparing techniques when the second ICS is utilized is shorter cephalad vessel length if revision of the anastomosis is required[13,15].

Direct anastomosis of the free flap to internal mammary perforator branches (IMPB) has been described by several authors[14,17,22]. Munhoz *et al.* reported on five patients who underwent anastomosis of SIEA flaps to the 2nd intercostal space IMPB with no immediate complications[17]. All patients were evaluated with preoperative CT scan to evaluate both the donor superficial inferior epigastric artery and vein, as well as the recipient pectoralis muscle perforators and their course[17]. Rad *et al.* discussed a series of nine patients who underwent IMPB anastomosis using a coupler for both arterial (1.5 mm-2.0 mm) and venous (2.0 mm to 3.0 mm)[18]. Handheld Doppler was used to preoperatively map perforators which were then explored for suitability for anastomosis, typically at the second and third ICS[18].

The concern for chest wall deformity may be alleviated with suturing of the flap over the area of rib resection, utilizing a rib-sparing technique, or using intercostal perforators as recipient vessels. While contour deformity and chronic pain have been described, these have not been noted in the senior author's practice with rib-resection at the 3rd or 4th rib and suturing of the flap medially to the chest wall to cover the defect. This allows for a widened exposure, which can be beneficial in the case of microsurgical education of trainees as it facilitates the ease of anastomosis.

MASTECTOMY SKIN FLAP NECROSIS

Evaluating the viability of mastectomy skin flaps prior to reconstruction is important to try to minimize mastectomy skin flap necrosis (MSFN) or massive skin necrosis (> 30% of the breast), as these complications can lead to prolonged healing and the need for additional interventions. In autologous reconstruction, this is particularly important during an immediate reconstruction. Risk factors that have been identified to contribute to MSFN include smoking[23-25] and increased BMI[25,26]. Nykiel *et al.* reviewed 944 autologous breast reconstructions including 204 free flaps and radiation was not a significant factor in the development of MSNF which occurred in 30% of the free flap cases[25]. Patel *et al.* discussed the treatment of 12 patients (of 805 reviewed), including 15 breasts (of 1,076 reviewed), who developed massive MSFN after autologous breast reconstruction between 1997 and 2010[23]. Of the patients who developed MSFN, 41.7% were current smokers and 16.7% were former smokers at the time of preoperative evaluation. Treatment initially started with allowing an eschar to form and separate. Antibiotics were only started for secondary cellulitis. Wound healing varied from 30 to 300 days, with 87% of the patients requiring late scar revision at an average of 8.9 months after initial surgery[23]. Nykiel *et al.* published a treatment algorithm for MSFN in 2014, recommending surgical intervention if wound healing was anticipated to be greater than 3 weeks[25]. Regression analysis showed full-thickness wounds greater than 6 cm^2 and partial-thickness wounds greater than 5 cm^2 took longer than 21 days to heal without clinical debridement and closure[25].

Given the significant impact on healing time, increased clinical care, potential for additional procedures, and impact on patient satisfaction caused by MSFN, several modalities have been evaluated to try to decrease the incidence. The use of indocyanine green fluorescence angiography (ICGFA) has been demonstrated to reduce the rate of MSFN to 13% from 23.4% in skin-sparing mastectomies undergoing reconstruction, effectively reducing those requiring reoperation from 14% to 6%[27]. A 2018 systematic review evaluated publications reporting clinical judgment versus indocyanine green (ICG) or fluorescein for rates of MSFN and reoperation. Clinical judgment had a mean of 19.4% MSFN and 12.9% reoperation. ICG and fluorescein had mean rates of MSFN of 7.9% and 3%, and mean rates of reoperation of 5.5% and 0%, respectively. Of note, only a single study evaluating the use of fluorescein was included in the review (34 breasts) compared to 13 studies using ICG (652 breasts)[28]. Additional imaging modalities that have been explored include hyperspectral imaging, which found a cutoff of tissue oxygenation at a depth of 1 mm (StO2%) < 36.29% led to a greater than 50% chance of mastectomy skin flap necrosis[29].

At our institution, the preferred method for evaluation of mastectomy skin flaps, in addition to clinical judgment, for immediate flap reconstruction is ICG fluorescence angiography (ICGFA). We also utilize ICGFA for flap evaluation and perforator selection. The majority of flaps at our institution are performed in a delayed fashion, which eliminates this issue. In the case of immediate flap reconstruction, if there is a concern for significant MSFN, then a delayed inset of 5-7 days can be performed. We have also used nitroglycerin paste when there is a concern about the perfusion of the nipple-areolar complex following nipple-sparing mastectomy with immediate DIEP flap reconstruction.

INFECTION

Postoperative infections can be classified as surgical site, deep surgical site, or organ space infection. A retrospective American College of Surgeons (ACS) National Surgical Quality Improvement Project (NSQIP) database analysis in 2021, which included 1924 free flap breast reconstructions, found adjusted rates of 2.3%, 1.3%, and 0.3%, respectively, within 30 days of surgery[30]. The effects of radiation on infection rates have been mixed, with some studies showing increased infection rates versus non-radiated fields (4% *vs.* 0.5%)[31], while other studies have demonstrated no difference in placing a flap in a previously irradiated field[32]. Active smoking and body mass index (BMI) have also been reported as risk factors for postoperative infection[33]. In 2010, Reiffel published the results of a survey of the American Society for Reconstructive Microsurgery related to the use of peri-operative antibiotics. It was found that for microsurgical breast reconstruction, the first choice was a first-general cephalosporin for patients with no known allergies (93.5%), and clindamycin (79.5%) or vancomycin (20.5%) as the choice for patients with a penicillin allergy. Duration of antibiotic coverage varied greatly from a single dose (5.3%), < 24 h (26.7%), 1 to 3 days (33.3%), 4 to 5 days (12.0%), > five days (4.0%), and until drain removal (18.7%)[34]. Liu *et al.* compared a cohort of peri-operative antibiotics for 24 h versus greater than 24 h (median 10 days) in microsurgical breast reconstruction and found no difference in surgical site infection (15.5% *vs.* 19.5%, P = 0.47)[35]. Additional studies have yielded similar results with no significant difference in SSI for patients receiving 24 h of antibiotics versus greater than 24 h in autologous breast reconstruction[36] and DIEP flap reconstruction specifically[37].

The current practice at our institution is continuing antibiotics until drain removal. This remains an uncommon complication of autologous breast reconstruction in our practice, even with the use of mesh for reconstruction of the abdominal donor site. We presently require three months of preoperative smoking cessation, a BMI of less than 35 kg/m^2, and a hemoglobin A1C of < 7.0 with the goal of reducing the incidence of postoperative surgical site infection.

PYODERMA GANGRENOSUM

Pyoderma gangrenosum (PG) is a rare complication in free autologous breast reconstruction. First described by Brunsting in 1930, PG is a neutrophilic dermatosis characterized by ulcers, bullae, and/or pustules[38]. It can present very similar to a surgical site infection and even mimic a necrotizing soft tissue infection, making diagnosis difficult. Traditionally, PG has been a diagnosis of exclusion. Several diagnostic criteria have been proposed to aid in the diagnosis of PG. Su *et al.* proposed two major criteria and four minor criteria, with diagnosis requiring both major and at least two minor criteria[39]. A Delphi consensus in 2018 proposed one major and eight minor criteria, with a diagnosis made when the one major and four of eight minor criteria were met[40]. Table 1 summarizes the major and minor criteria for each.

A 2016 review of published cases of postoperative pyoderma gangrenosum (PPG) found a lower association with systemic disease than other forms of PG. Additionally, it was noted PPG is often misdiagnosed, which may lead to initiation of antibiotic drug therapy and debridement with possible subsequent morbidity[41].

Table 1. Major and minor criteria for diagnosis of pyoderma gangrenosum

	Major criteria	Minor criteria
Su *et al.*[39]	(1) Rapid progression of painful, necrolytic cutaneous ulcer with an irregular, violaceous, and undermined border (2) Other causes of cutaneous ulceration have been excluded	(1) History suggestive of pathergy or clinical finding of cribriform scarring (2) Systemic diseases associated with PG (3) Histopathologic findings (sterile dermal neutrophilia, ± mixed inflammation, ± lymphocytic vasculitis (4) Treatment response (rapid response to systemic steroid treatment
Delphi consensus[40]	(1) Biopsy of the ulcer edge demonstrating neutrophilic infiltrate	(1) Exclusion of infection (2) Pathergy (ulcer occurring at sites of trauma) (3) Personal history of inflammatory bowel disease or inflammatory arthritis (4) History of papule, pustule, or vesicle that rapidly ulcerated (5) Peripheral erythema, undermining borders, and tenderness at sites of infection (6) Multiple ulcerations (at least one occurring on an anterior lower leg) (7) Cribiform scars at sites of healed ulcers (8) Decrease in ulcer size within one month of initiating immunosuppressive medications

A 2017 case report and systematic review by Zelones *et al.* of PG in autologous breast reconstruction identified 16 prior cases of PG with the average onset at 10 days postoperatively with a range of two days to two months[42]. Seven cases included fever and six included leukocytosis. Nine cases involved both donor and recipient sites, five cases involved the recipient breast only, and two did not specify. Only two cases reported positive wound cultures. Treatment modalities included steroids, cyclosporin, hyperbaric oxygen, tacrolimus, calcineurin inhibitor, and zinc oxide. The reported case also demonstrated fever, leukocytosis, erythema, bullae, and crepitus[42]. Due to difficulty in making a diagnosis, initial treatment with antibiotics and debridement prior to diagnosis of PG is common[42-48].

In 2019, Li *et al.* published a series of eight cases of postoperative PG after free abdominal tissue transfer for breast reconstruction[48]. The mean presentation was 3.9 days postoperatively, and symptoms included fever in six of eight, and leukocytosis in five of eight. As a component of PG is pathergy, or an exaggerated response to trauma/debridement, early diagnosis is important to break the cycle and initiate the appropriate treatment. Li proposed three factors that should raise suspicion for PG, including violaceous rash and ulceration at skin paddle inset and mastectomy flap, multi-site involvement (bilateral breasts or breast and abdomen), and finally a dramatic and immediate response to steroids or other immunosuppressive agents[48].

Pyoderma gangrenosum can be difficult to diagnose and suspicion should remain high in patients presenting with ulcerations and erythema of surgical sites, especially if more than one site is involved. Early biopsy of the wound edge can aid in diagnosis by evaluating for neutrophilic infiltration. Once there is a concern for possible PG, biopsy of the wound edge and consultation with Dermatology should be initiated.

BLEEDING COMPLICATIONS

A 2019 NSQIP analysis of 4,143 patients undergoing free flap reconstruction of the breast noted a bleeding complication rate of 12%, defined as receipt of at least one unit of packed or whole red blood cells from the start of the procedure to 72 h postoperatively. The rate was highest in immediate bilateral reconstruction (16.6%), followed by delayed bilateral reconstruction (12.8%), unilateral immediate reconstruction (10%), and finally unilateral delayed reconstruction (9.4%)[49]. A 2021 NSQIP analysis of patients undergoing breast reconstruction including 1924 patients undergoing free flap reconstruction found an adjusted rate of bleeding complications of 12.3%[30]. Chen *et al.* evaluated the intraoperative use of heparin during

microsurgical free flap reconstruction in 2008 and found that intravenous heparin administration prior to anastomosis did not lead to increased rates of hematoma or bleeding, but also did not decrease the rate of microvascular thrombosis[50].

In addition to requiring transfusions, bleeding may lead to hematoma formation and the need to return to the OR for evacuation. In order to try to reduce bleeding complications, the use of tranexamic acid (TXA) has been evaluated. In 2018, a meta-analysis of surgical trials evaluated the safety and effectiveness of TXA. The study showed the risk for transfusion was reduced by 38% in the TXA groups with no significant differences in mortality or thrombotic events[51]. Lardi *et al.* evaluated the use of TXA in microsurgical breast reconstruction[52]. The study compared patients who received up to 3 g of intravenous TXA intraoperatively and postoperatively to those that received no TXA. The use of TXA was determined by intraoperative and postoperative blood loss. Analysis of the two groups showed decreased blood loss in the TXA group (158.4 mL) versus control (231.5 mL) ($P < 0.001$) and a trend towards decreased hematoma of the breast (10.0% TXA versus 18.2% control), but this was not statistically significant ($P = 0.332$). There was no statistical difference in blood transfusions, deep venous thrombosis, or thrombosis of anastomosis[52].

Hematoma of the chest recipient site can be related to venous congestion. Chu *et al.* discussed the results of a retrospective review of reoperation for hematoma and/or venous congestion in head and neck reconstruction and breast reconstruction patients[53]. Of the 15 patients who developed both, 8 were separate occurrences, while 4 patients developed compression of the pedicle vein from the hematoma, and in the remaining 3 patients, it was believed that the venous congestion was the cause of the hematoma. For breast reconstruction, venous congestion leading to hematoma was more common than hematoma preceding venous congestion[53].

Meticulous hemostasis at the time of free flap reconstruction is vital to minimize hematoma formation or bleeding complications requiring transfusion. We have not adopted the routine use of TXA in microsurgical breast reconstruction. We administer a preoperative dose of aspirin, which is continued daily for 30 days, in addition to low-molecular-weight heparin while inpatient. The combination may contribute to bleeding in some patients. While hematomas do occur, in our experience, this seems to be most common in the setting of continuous heparin infusion following microsurgical thrombosis, anastomotic redo, or deep venous thrombosis/pulmonary embolism. Prompt identification and treatment of hematomas is important as it may be related to another issue, such as venous congestion or compression of the pedicle.

PNEUMOTHORAX

Dissection of the internal mammary vessels as recipients of autologous breast reconstruction poses a risk of injury to the parietal pleura and subsequent development of pneumothorax (PTX). The rate is overall low in autologous reconstruction, with literature primarily composed of case reports and case series[54-56]. Darcy *et al.* reported one pneumothorax in a series of 463 rib-sparing free flap reconstructions[14]. Clinical symptoms of pneumothorax can include decreased oxygen saturation, tachycardia, tachypnea, dyspnea, and difficulty ventilating the patient. Progression to tension pneumothorax will result in hypotension. Reekie *et al.* reported a case of tension pneumothorax after an extended latissimus dorsi flap with noted venous congestion of the flap in combination with progressive hypotension, tachycardia, low pulse oximeter readings, and increased ventilatory pressures[54]. The patient was treated with needle decompression and subsequent chest tube placement with noted rapid improvement in the flap venous congestion concurrent with physiologic improvement[54].

Several treatment algorithms have been published for the management of suspected pneumothorax intra-operatively[55,56]. The first step is to perform a bubble test by filling the cavity with saline followed by a breath hold by anesthesia. In a series of four pneumothoraces during free flap breast reconstruction identified at a single institution, this test was only noted to be positive in one patient diagnosed with pneumothorax based on postoperative chest X-ray[55]. If the bubble test is negative, then no additional intervention is required. If the bubble test is positive, the injury should be repaired by direct suture of the pleural tear, fascial graft or muscle/fascia flap, or fat plug as needed[55,56]. Repair should be performed over a catheter which is removed during positive pressure breath hold as the last suture is tied down. Bubble test should then be repeated to confirm the repair. Postoperative chest X-ray and clinical monitoring for signs of pneumothorax should be performed. If clinically significant pneumothorax develops postoperatively, the patient will require a chest tube. Careful coordination with the team placing the chest tube is vital as placement of a postoperative intercostal drain for pneumothorax was reported to occur immediately adjacent to the internal mammary vascular pedicle and vascular anastomosis[56].

Intraoperative concern for pneumothorax should prompt a bubble test and repair as needed. Venous congestion in a flap may be a sign of pneumothorax in an otherwise healthy flap[54] and is considered during the evaluation for the cause of venous congestion. Patients with concern for intra-operative pneumothorax should have postoperative chest x-ray completed. If chest tube placement is needed postoperatively, the microsurgical reconstruction team needs to carefully coordinate the placement of the chest tube to minimize potential injury to the flap and/or vascular pedicle.

CHYLE LEAK

With dissection of the internal mammary vessels, identified lymph nodes are typically removed. Removal of these lymph nodes interrupts the lymphatic channels, and in 2019, Long *et al*. reported a case of a chyle leak after delayed-immediate bilateral DIEP flaps[57]. The patient had a history of invasive ductal carcinoma of the right breast and was treated with a right modified radical mastectomy and left simple mastectomy with immediate placement of acellular dermal matrix wrapped tissue expanders followed by adjuvant radiation. On postoperative day five following the DIEP flaps, the left breast drain changed to cloudy but low volume output and she was discharged home. The next day, she had significant swelling of the left breast surgical site, which improved after 600 mL of milky fluid spontaneously decompressed through the left-sided drain. Chyle leak was suspected and confirmed after testing the fluid for triglycerides and chylomicrons (> 1300 mg/dL and present). She had foam tape applied to the area to try to compress the leak and was started on a low-fat, high-protein diet with resolution of the milky drainage on postoperative day 12. Her drain was subsequently removed on postoperative day 16 and she remained on a low-fat diet for 3 weeks. Their recommendation is to deal with lymphatic vessels and nodes deliberately with the use of clips as opposed to cautery or sharp dissection during internal mammary vessel dissection[57].

For a patient who is otherwise clinically doing well without evidence of infection but experiences milky output from a drain after starting a regular diet, chyle leak should be suspected and evaluated with fluid testing for triglycerides and chylomicrons (> 110 mg/dL and presence is confirmatory) as was done in this case. Treatment may start with a diet low in long-chain triglycerides with supplementation of medium-chain triglycerides[58] as well as the addition of somatostatin or octreotide. If the leak persists beyond 2 weeks or the volume is greater than 500 to 100 mL per day, more aggressive measures may be required, such as a percutaneous approach with coiling of the thoracic duct or surgical intervention to identify the leak and ligate the offending vessels.

POSITIVE INTERNAL MAMMARY NODE METASTASIS

The internal mammary vessels are a popular choice as recipient vessels for autologous free flap breast reconstruction. During the dissection of the internal mammary vessels, lymph nodes may be identified, and for patients with a history of breast cancer, the concern for possible metastasis is present. In 2011, Yu *et al.* discussed their institution's experience with opportunistic internal mammary lymph node biopsy during microsurgical breast reconstruction[59]. They noted 3 prior studies reporting biopsy of internal lymph nodes, with a total of 9 containing metastasis out of 49 biopsied. Of 293 free flap breast reconstructions, 43 patients had internal mammary lymph nodes identified during dissection of the internal mammary vessels, with a total of 6 of these patients having metastasis in the sampled nodes. The treatments varied in their patients, from radiation to the chest wall and internal mammary lymph node chain, with some patients also receiving radiation to the supraclavicular fossa, chemotherapy, or no additional treatment. Of the 38 sampled nodes in the remaining 37 patients, which were negative for metastasis, five were noted to have silicone granulomas in patients with prior implant-based breast reconstruction, and the remaining 33 showed inflammatory changes only. It was noted that there was no macroscopic difference identified between these nodes[59]. Wright *et al.* reported on routine internal mammary lymph node sampling in 264 autologous breast reconstructions (204 patients)[60]. All removed lymph nodes were clinically unremarkable without macroscopic evidence of tumor involvement. Six patients had positive metastatic disease, resulting in an alteration of their adjuvant treatments[60].

We recommend a pathologic examination of any lymph nodes identified during the dissection of the internal mammary vessels and referral to our oncology colleagues for treatment options in the event of positive nodes.

CONCLUSION

Complications at the recipient site of autologous breast reconstruction can include common surgical complications (infection, bleeding), recipient site-specific issues (contour deformity, mastectomy skin flap necrosis), and uncommon complications (pneumothorax, pyoderma gangrenosum, chyle leak, positive internal mammary nodes). It is important to understand the risks, contributing factors, and treatments for each. Our hope is this review reinforces treatment options for more common complications as well as increases awareness of less well-known complications. High clinical suspicion for uncommon complications can reduce the time to diagnosis and potential additional morbidity from delay in diagnosis and appropriate treatment.

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Authors' contributions

Literature review and compilations for each topic, introduction, and conclusion: Leach CM
Personal and institutional experiences and recommendations for each topic, introduction, and conclusion: Collins MS

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Ethical approval and consent to participate

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Consent for publication

Not applicable.

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