Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

The risk of dying of pneumonia is too high for low-risk surgery. It seems that the average person infected with coronavirus contaminates 2 to 3 people. In light of my considerations, only emergency and urgent operations should be performed. The strict observance of protective measures and the interruption of elective surgical procedure will enhance the security and safety of patients and health care personnel. While the infection advances in other countries, the social distancing has brought its first positive effects in Italy. In the meantime, we learned the importance of a hug with friends and family, solidarity, and time. We will win this war and see the rainbow. It's gonna be ok!

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See Letter page e39.

Commentary: Compliance with the American Association for Thoracic Surgery guidelines will prevent sternal wound infections and minimize postoperative complications in cardiac surgery patients during the COVID-19 pandemic

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CENTRAL MESSAGE

Compliance with the AATS guidelines will prevent sternal wound infections and minimize postoperative complications in cardiac surgery patients during the COVID-19 pandemic.

During the current coronavirus disease 2019 (COVID-19) pandemic, patients who have required care in the intensive care unit (ICU) have tended to be older (mean age 66 years) and have a greater incidence of obesity, smoking, and underlying cardiovascular disorders, including diabetes, hypertension, hyperlipidemia, chronic pulmonary disorders, and cardiac disease.[1] In view of these associated comorbidities, a percentage of these patients will require urgent or emergent cardiac surgery for acute coronary syndromes, valvular dysfunction, as well as surgery for aortic dissections and thoracic aneurysms. Unfortunately, the risk factors for mediastinitis following cardiac surgery—obesity, smoking, diabetes, emergent surgery, and hospitalization before surgery—are similar to the profiles of patients who are most likely to require cardiac surgery during the COVID-19 pandemic.[2] This commentary will review how compliance with the American Association for Thoracic Surgery (AATS) Guidelines for the Prevention of Sternal Wound Infections[3] will help to minimize infections and wound complications and also help to reduce all postoperative complications in patients requiring cardiac surgery during the COVID-19 pandemic.

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PREOPERATIVE SCREENING

Testing for the COVID-19 Virus

There are currently no society guidelines for screening patients with COVID-19 before cardiac surgery. In view of the fact that patients requiring surgery may be asymptomatic carriers of the virus, it is not unreasonable that all patients undergoing cardiac surgery during the COVID-19 pandemic be screened for the virus. This will identify those patients who will require isolation perioperatively and those health care workers who must wear personal protective equipment in caring for these patients. If available, surgery should be performed in an operating room (OR) with a negative-pressure environment to reduce the dissemination of the virus to locations outside the OR.[4] If a negative-pressure room is not available, a greater frequency of air exchanges will help to more rapidly reduce the viral load within the OR. In addition, it will be important to report the profiles, surgical procedures, and outcomes of COVID-19 patients undergoing cardiac surgery to national databases, such as the Society of Thoracic Surgeons (STS), to better understand the risk for patients and health care workers.

Screening and Treating All Distant Infections Before Surgery

The AATS guidelines give a class I recommendation that all distant, extrathoracic infections should be treated before cardiac surgical procedures. This should include all respiratory tract infections. While it may not be possible to delay surgery to achieve a full course of antibiotic therapy in COVID-19 patients until the infection has resolved, it important that cultures be obtained and the appropriate antibiotics instituted before surgery. Since the respiratory system is the most common site for severe COVID-19 infections, and in view of the fact that a significant number of patients will have underlying pulmonary disease and a history of smoking, sputum specimens should be obtained in addition to nasopharyngeal swabs to detect underlying pulmonary bacterial infections that could contribute to postoperative pulmonary insufficiency requiring prolonged ventilatory support. Since COVID-19 patients tend to be older, they may suffer from benign prostatic hypertrophy, and preoperative urine cultures should also be obtained in addition to routine urine analyses.

Screening and Treating *Staphylococcus* Nasal Carriers

The AATS guidelines recommend (class I) that all cardiac surgery patients should have nasal swabs or polymerase chain reaction (PCR) testing, if available before surgery, and that routine intranasal mupirocin administration is recommended for all cardiac surgery procedures in the absence of PCR testing or nasal cultures positive for *Staphylococcus* colonization.

Intranasal mupirocin results in immediate decolonization of methicillin-sensitive *Staphylococcus aureus* in >90% of patients[5] and in 45% to 50% of methicillin-resistant *Staphylococcus aureus* (MRSA) patients.[6] Intranasal mupirocin initiated within 24 hours of surgery, continued for 5 days, and in combination with chlorhexidine gluconate bathing has been shown to significantly decrease the incidence of deep sternal wound infections following cardiac surgery.[7] Since nasal mupirocin has no effect in patients who are not nasal *Staphylococcus* carriers, it should only be used in those patients who have either a positive nasal culture or PCR assay. In those patients who require emergent surgery in whom the results of a nasal culture are not available at the time of surgery, intranasal mupirocin may be initiated before surgery and continued in the postoperative period until the culture results are available. If the cultures are negative, mupirocin should be discontinued to avoid mupirocin resistance (MR), which can decrease the effectiveness of mupirocin to eradicate staph infections and result in the emergence of more-virulent organisms.

In this issue of the *Journal*, Mayeur and colleagues[8] report that in view of the COVID-19 pandemic, they have decided to suspend all preoperative nasal swab screening for cardiac surgery patients and will consider these patients as *Staphylococcus* carriers and treat them all with intranasal mupirocin. This is being initiated to protect health care workers from being exposed to sputum containing the COVID-19 virus. The existing literature would not support this extended use of intranasal mupirocin to all patients undergoing cardiac surgery. MR to staph species is increasing throughout the world. In Canada, the proportion of MR increased from 1.6% in 1995-1999 to 7.0% in 2000-2004.[9] When mupirocin was administered to all patients during an MRSA epidemic in the United States, the incidence of MR increased over a 3-year period from 2.7% to 65%.[10] In Brazil, the "blanket" use of mupirocin to eradicate staph species in all high-risk patients resulted in a 65% incidence of MR.[11] This was decreased to 15% over a 5-year period when only staph nasal carriers were treated.

It was hypothesized that short-term intranasal mupirocin, used as part of a perioperative prophylactic regimen, might not be associated with the emergence of MR. However, several studies have shown that when mupirocin is indiscriminately used as prophylaxis before surgical procedures, the prevalence of MR is increased. Bathoorn and colleagues[12] looked at the effects of short-term mupirocin therapy (24 hours before surgery and twice daily for 5 days postoperatively) given to all surgical patients over a 5-year period. There was a significant increase of high-level MR to coagulase negative *Staphylococcus* from 8% to 22%. Furthermore, isolates with high-level MR were

less susceptible to ciprofloxacin, clindamycin, and erythromycin. The authors concluded that not only could the routine use of mupirocin for prophylaxis in all surgical patients result in increased MR, it could also diminish the effectiveness of perioperative antibiotics for organisms other than staph species. Hetem and colleagues[13] studied the effects of nasal mupirocin combined with chlorhexidine soap for 5 days as surgical prophylaxis given to all patients irrespective of their *Staphylococcus aureus* carrier status. High-level MR was 21% in coagulase-negative patients before mupirocin but increased to 43% after mupirocin therapy. MR was associated with resistance to oxacillin, aminoglycosides, clindamycin, ciprofloxacin, trimethoprim/sulfamethoxide, and rifampicin. In a study from South Africa, Wasserman and colleagues[14] found that the indiscriminate use of mupirocin to decolonize all patients increased the incidence of high-level MR to 23.3% and was associated with resistance to cloxacillin and fluroquinolones. Rudresh and colleagues[15] found that when mupirocin was used to treat all patients, high-level MR to *S aureus* was 10.5% and was associated with resistance to penicillin, erythromycin, ciprofloxacin, clindamycin, and amoxicillin. They concluded that the use of mupirocin should be based on nasal cultures and that the widespread use of mupirocin should be avoided.

The indiscriminate use of mupirocin prophylaxis in cardiac surgery will increase the emergence of MR and limit its beneficial effects in reducing deep sternal wound infections. It will lead to the emergence of more-virulent organisms that may be resistant to those systemic antibiotics currently used for prophylaxis in cardiac surgery. Mayeur and colleagues cite concerns for health care workers as the reasons for not obtaining nasal swabs. However, during the COVID-19 pandemic, all patients scheduled for cardiac surgery who have tested positive for the virus, or in whom the viral status is unknown, should all be treated by health care providers using personal protective equipment. The same precautions used to intubate these patients for surgery should also be used when obtaining nasal swabs to detect staph carriers.

In summary, the indiscriminate use of intranasal mupirocin in the absence of nasal staphylococcus carriers is harmful and should be avoided. This practice would be given a class III recommendation.

PERIOPERATIVE GLYCEMIC CONTROL

Optimizing glycemic control is essential to not only eliminate all sternal wound infections but also to decrease morbidity and mortality in COVID-19 patients undergoing cardiac surgery, especially since a significant number of these patients will have diabetes mellitus and suboptimal glycemic control. The following are class I recommendations from both the AATS and STS guidelines[3,16]:

- Optimizing glycemic control is recommended in patients with elevated HbA1c levels (>7.5) and serum glucose levels >200 mg/dL before any cardiac surgery procedure.
- All patients undergoing coronary artery bypass graft surgery should have a fasting glucose and an HbA1c before surgery.
- During surgery, insulin infusions should be instituted to maintain serum glucose <180 mg/dL.
- Continuous insulin infusions should be initiated in the ICU for at least 24 hours to maintain serum glucose <180 mg/dL.
- Patients who require >3 days of ICU care due to ventilatory, inotropic, or mechanical support or the need for antiarrhythmic agents should have serum glucose levels <150 mg/dL.

It is anticipated that COVID-19 patients will require longer periods of ICU, ventilator, inotropic, and mechanical support as well as the need for renal-replacement therapy. Van den Bergh and colleagues[17] have shown that this group of patients will benefit from more stringent glycemic control (serum glucose <150 mg/dL) and that this will result not only in decreased sternal wound infections but a significant decrease in operative mortality.

PERIOPERATIVE ANTIBIOTICS

Patients undergoing cardiac surgery during the COVID-19 pandemic should adhere to the following recommendations derived from both the AATS and STS guidelines[3,18,19]:

- A cephalosporin, either cefazolin or cefuroxime, should be given intravenously within 60 minutes before the skin incision and be continued for no longer than 48 hours (class I).
- Vancomycin is reserved for patients with a history of type 1 allergic reactions to beta-lactam agents or in cases in which MRSA is a special concern (class IIa).

Patients with COVID-19 may be more likely to be in the hospital for >3 days before their surgery and/or transferred to a tertiary hospital or an ICU. MRSA may be a special concern in these patients, and administering vancomycin to these patients is not unreasonable, especially in those patients who will require a valve prosthesis or a vascular graft.

- Vancomycin is not recommended as the sole prophylactic antibiotic for cardiac surgery procedures (class III).

Vancomycin coverage is essentially limited to gram-positive bacteria, especially MRSA and methicillin-resistant *Staphylococcus epidermidis*. An aminoglycoside should be added for gram-negative coverage. This is especially important for COVID-19 patients who may already have gram-negative organisms in their tracheobronchial tree as a result of their viral infection.

- An aminoglycoside should be added for 1 preoperative and at most 1 postoperative dose for gram-negative coverage when vancomycin is the primary prophylactic antibiotic (class IIb).

Since aminoglycosides have been associated with nephrotoxicity and ototoxicity following cardiopulmonary bypass, a single postoperative dose of no more than 4 mg/kg should be administered. Subsequent doses should be administered based on culture results.

- Vancomycin should be administered between 60 and 120 minutes before the incision and at most for only 1 additional dose when it is used with a cephalosporin (class I).
- A cephalosporin should be administered within 60 minutes of a cardiac surgical procedure and redosed for procedures lasting >4 hours (class I).

Patients undergoing cardiac surgery during the COVID-19 pandemic are more likely to require more extensive procedures requiring extended periods of cardiopulmonary bypass and surgeries lasting more than 4 hours. Intraoperative redosing of cefazolin has been found to reduce infections by 16% in procedures lasting more than 4 hours and following 120 minutes of cardiopulmonary bypass.[20,21]

LOCAL STERNAL TREATMENT

- Topical antibiotics should be applied to the cut edges of the sternum upon opening and before closing in all cardiac surgical procedures involving a sternotomy (class I).
- Bone wax should not be applied to the cut edges of the sternum at any time (class III).

Topical antibiotics, such as vancomycin paste, applied to the cut edges of the sternum upon opening and closing, have been found to dramatically reduce the incidence of all sternal wound infections.[22] In contrast, bone wax acts as a foreign body, prevents bone union, and has been found to be an independent risk factor for sternal dehiscence and wound infections.[23] It should not be used in patients undergoing a sternotomy, especially in those infected with the COVID-19 virus.

POSTOPERATIVE NUTRITION

A low serum albumin is one of the strongest predictors of postoperative morbidity and mortality following cardiac surgery. Patients with a preoperative serum albumin <2.5 mg/dL have a significant increase in operative mortality and sternal wound infections.[24] Whenever possible, surgery should be delayed for 7 to 10 days to allow for implementation of nutritional support, preferably through the enteral route, which avoids intravascular catheter infections and metabolic complications. However, patients undergoing cardiac surgery during the COVID-19 pandemic will require urgent and emergent procedures. Many of these patients may have already been in the hospital or in an ICU on ventilator support for days before surgery. Patients with an albumin <2.5 mg/dL, those with weight loss >10% of body weight within 6 months, and who have evidence of muscle wasting will benefit the most from early postoperative nutritional support.[25] These patients will more likely require prolonged ventilator support, so that enteral feedings should be initiated as soon as hemodynamic stability has been achieved.

CONCLUSIONS

Cardiac surgery performed during the COVID-19 pandemic will force surgeons to operate in uncharted waters. Adherence to the AATS guidelines for prevention of wound infections in conjunction with the STS guidelines for perioperative glycemic control and the STS guidelines for antibiotic usage will provide a pathway for surgeons to safely navigate a postoperative course to decrease postoperative infections, minimize complications, and improve survival.

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