Clinical and Ethical Considerations in the Care of an Elderly Patient With Critical Left Main Disease and Shock

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A 73-year-old white woman presented to a community hospital emergency department with 7 days of productive cough, dyspnea, and fatigue. Her vital signs were as follows: temperature, 99.9°F; pulse, 100 bpm; respiratory rate, 16 breaths per minute; blood pressure, 153/78 mm Hg; and oxygen saturation, 97% on room air. Her jugular venous pressure was normal; her lungs were clear; and her cardiac examination demonstrated tachycardia but no murmurs or gallops. Extremities were warm without edema. Her complete blood count was normal with the exception of a mild leukocytosis (13 000 cells/mm³). Her electrolytes and renal function were normal (creatinine, 0.8 mg/dL). Her troponin T level was <0.01 ng/mL. A chest radiograph demonstrated a subtle right middle lobe infiltrate. Intravenous ceftriaxone and azithromycin were given for community-acquired pneumonia.

Relevant medical history included hypertension, hyperlipidemia, and an ischemic stroke 21 months previously that resulted in residual right hemiplegia. She had no history of cardiac disease. The patient was married and lived at home with her husband, who assisted her with many of her activities of daily living.

While in the emergency department, the patient became unresponsive, and ventricular fibrillation was detected on the telemetry monitor. Cardiopulmonary resuscitation was delivered for 3 minutes, and sinus rhythm was restored after 1 defibrillatory shock. The patient was subsequently intubated for airway protection and loaded with intravenous amiodarone, and an ECG was obtained (Figure 1). Hypotension ensued over the next 10 minutes, and dopamine was initiated for hemodynamic support. Requests were made to transfer the patient to a tertiary care facility with 24-hour cardiac catheterization capability.

Dr Yeh: The patient’s initial presentation was consistent with possible community-acquired pneumonia. However, the occurrence of ventricular fibrillation, aborted sudden death, and ensuing shock dramatically alters the clinical priorities and calls for a rapid diagnostic and therapeutic plan. Although a number of processes, including metabolic abnormalities, drug effects (eg, QT prolongation), and noncoronary structural heart abnormalities, may be associated with ventricular arrhythmias, acute myocardial ischemia must be considered likely in this elderly patient with known cardiovascular disease.

The ECG demonstrates diffuse ST-segment depressions across the precordial leads, an ominous finding consistent with a large amount of myocardium at risk. Subtle ST-segment elevation is also present in lead aVR, a finding that is classically associated with left main coronary involvement and that adversely predicts short- and long-term mortality in patients with acute coronary syndromes. There is isolated 1-mm ST-segment elevation in lead III, but this is not sufficient for the diagnosis of ST-elevation myocardial infarction because elevation is not present in ≥2 contiguous leads.

Given the development of cardiac arrest and shock, she should be transferred to a facility capable of providing emergent coronary angiography, possible mechanical circulatory support, and percutaneous coronary intervention (PCI). There is no indication for systemic thrombolysis based on the ECG findings; if findings consistent with acute ST-segment elevation myocardial infarction were present, transfer for primary PCI would still be the preferred strategy if the time delay is acceptable owing to the presence of hemodynamic instability. Because of the patient’s history of stroke with residual debilitation, the high-risk nature of her presentation, and her inability to communicate while intubated, a careful discussion with the patient’s family about her desires for aggressive care is indicated.

Patient presentation (continued): Phone conversations between the receiving interventional cardiologist, the emergency room physician, and the patient’s daughter revealed that the patient had been considering a code status of “do not resuscitate.” This was driven primarily by the fact that her rehabilitation course after her stroke 21 months prior was prolonged and difficult, and it had taken her nearly 1 year to become self-sufficient in performing her activities of daily living. Nonetheless, these decisions had not been finalized, and coronary angiography was ultimately pursued in accordance with the family wishes.

The patient was bolused with unfractionated heparin and administered 325 mg aspirin. She was transferred to a neighboring tertiary care hospital at 1 AM for emergency coronary
angiography. No thienopyridines were given because of the possibility of surgical disease based on the presenting ECG. Her hemodynamic status worsened en route, and on arrival to the catheterization suite, she required large doses of dopamine and norepinephrine.

Right femoral artery access was obtained, and a 6F sheath was placed. On engagement of the left main coronary artery with a left Judkins catheter, severe pressure dampening occurred. Angiography demonstrated a concentric 90% stenosis involving the ostial left main artery (Figure 2A); the remaining left coronary system had diffuse irregularities without significant disease. Left-to-right collaterals supplying the distal right coronary artery were also noted (Figure 2B). Right coronary angiography demonstrated a diffuse 70% stenosis in the proximal segment followed by an occlusion in the midsegment (Figure 2C). Left subclavian angiography was performed to identify and assess the adequacy of the left internal mammary artery to serve as a conduit for bypass grafting. The subclavian and left internal mammary artery were widely patent. However, during this angiogram, the patient again developed ventricular fibrillation that was promptly treated with defibrillation. Contralateral femoral artery access was immediately obtained; an intra-aortic balloon pump (IABP) was placed, and counterpulsation was initiated. The patient remained tenuous but vasopressor requirements were stable.

Dr Yeh: Angiography has confirmed the presence of severe left main disease in addition to an occluded right coronary artery. The patient is clinically in cardiogenic shock as a result of profound global myocardial ischemia caused by

Figure 1. ECG showing diffuse ST-segment depressions in the precordial leads and mild ST-segment elevation in lead aVR. There is also isolated 1-mm ST-segment elevation in lead III with nonpathological Q waves in the inferior leads.

Figure 2. Coronary angiography. A, A significant ostial left main lesion is present. Severe pressure dampening occurred on engagement with a 5F diagnostic Judkins left catheter. B, The distal right coronary artery (arrows) fills retrograde from left-to-right collaterals. C, The right coronary has moderate to severe diffuse disease in the proximal segment followed by an occlusion (yellow arrow highlights the stump) in the midsegment just after the takeoff of a ventricular marginal branch.
critical stenosis of the left main that supplies nearly 100% of her myocardium.

Urgent revascularization is indicated, but there are several caveats that complicate decision making at this point. First, clarification of the patient’s goals and wishes is necessary because she was informally discussing care limitations with her family in the months preceding this presentation. Second, the patient’s anatomy is surgical based on the presence of significant left main disease, and current guidelines recommend emergency coronary artery bypass grafting (CABG) in these patients with shock or life-threatening arrhythmias. Although her operative risk is substantial given her current clinical status, this risk may not be prohibitive for CABG. Additionally, emergency bypass may be logistically more challenging given the off-hours presentation because significant resource mobilization would be needed to prepare and organize the operative team. Finally, in terms of percutaneous options, the right coronary occlusion has an acute thrombotic appearance, but the ECG and clinical status of the patient implicate the left main as the problematic lesion. In such cases, identification of the culprit lesion may not be clear, and multiple culprit lesions are known to occur during acute coronary syndromes.

Patient presentation (continued): The on-call cardiac surgeon was contacted to assess if immediate, emergency CABG was an option, assuming the family would consent to this. The patient was deemed not to be a suitable candidate for emergent CABG because of prohibitive operative risk and the delay required to mobilize the operating room. A discussion was had with the patient’s husband and daughter to explain the findings and options moving forward. Some uncertainty remained as to whether the patient would desire to have a high-risk procedure performed that could potentially spare her life.

The Patient’s Daughter: Our primary goal that night was to make a medical decision that gave my mother the best chance of survival but considered her weakened condition from a stroke 21 months previously. A year and a half earlier, my mother had been working full time as the owner and director of a daycare center for 24 children when she awoke with a right foot drop and found that she could not write numbers the same size on her deposit slip. Over the next 2 days while hospitalized, she lost movement in the entire right side of her body. With therapy, she regained the ability to walk with a hemi walker and supervision, but she did not regain the use of her right hand and arm. Both my father and I wanted my mother to live, but we were afraid of making a decision that would leave her in a worsened condition. We wanted to make a decision that would allow my mother to live, but leave her in a worsened condition. We wanted to make the best choice for her, not just choose the option with the highest chance of survival. My father and I also did not want to make a selfish choice because we were not ready to let her go. We had to balance benefits and invasiveness of the procedure and the likelihood of recovery. We needed to understand these risks and needed more time to digest the information provided to us.

Patient presentation (continued): The patient was transferred to the cardiac intensive care unit while the interventional team and the patient’s family formalized decisions about revascularization. Her cardiac biomarkers drawn at the time of angiography showed a creatine kinase of 493 U/L, creatine kinase-MB of 51.3 ng/ml, and troponin of 1.71 g/dL. A bedside echocardiogram performed shortly after arrival to the unit revealed a left ventricular ejection fraction of 21%. The anteroseptal, septal, and inferior walls were hypokinetic. The aortic valve was sclerotic without significant stenosis or insufficiency. Trace mitral regurgitation was present. The patient continued to deteriorate. By 4 AM, 2 hours after arrival to the unit, she was on maximal doses of vasopressin, norepinephrine, and dopamine.

The family was informed in greater detail about the gravity associated with her condition, the risks associated with PCI, and the uncertain nature of the recovery process. The interventional team estimated her in-hospital mortality for PCI on the basis of several published risk-prediction models, with risk ranging from 29% to 92% (Table). The interventional team presented the higher estimate of risk to the family because this model was thought to best incorporate clinical characteristics of the patient’s presentation and was the basis of the state’s annual public report on hospital PCI risk-adjusted mortality rates. The family elected to proceed with PCI despite the very high risk of death. Privately, the interventional team expressed relief that the risk of mortality predicted with the state-derived model seemed to adequately represent the apparent risk of the patient to clinicians at the bedside, as a death in this case would have a less adverse impact on the hospital’s measured performance than if the predicted mortality had been assessed to be lower.

Dr Yeh: Without revascularization, death is imminent, and even with revascularization, the patient has a very high mortality rate given the maximal doses of 3 vasopressors, the unclear neurological status after cardiac arrest, and the baseline comorbidities of the patient. However, the estimation of the patient’s likelihood of surviving PCI is an imprecise science. Prior observational series have demonstrated mortality rates of 40% to 45% in patients with left main–associated cardiogenic shock, even after successful PCI. However, the translation of such data to the current clinical scenario is difficult because...
these patients were on average younger, had less ventricular dysfunction, and were an inherently distinct population given that they were selected for, and felt to be salvageable with PCI. Risk scores implementable at the bedside may be applied to more accurately gauge an individual’s risk of an outcome with a given therapy. However, the divergent estimates of risk from the different validated risk calculators highlight the inherent limitations of applying such tools on an individual-patient basis. In this case, the concordance of the clinicians’ beliefs of the risks of the procedure with the risk estimates from the model used as the basis of the state public reporting risk-adjustment methodology provided reassurance to the clinicians. When discordance exists between these two, however, the treating physicians may be forced to decide between making medical decisions that are in accordance with the family’s wishes and those that may be more aligned with personal or institutional goals. Such discordance may lead to risk aversion and withholding of potentially life-saving interventions.

Patient presentation (continued): The patient was returned emergently to the catheterization laboratory for PCI. Although the right coronary artery occlusion was believed to be acute, the left main was deemed to be the more important vessel because it was subtending such a large proportion of functioning myocardium. The PCI strategy was to address the left main primarily in attempt to lessen the profound myocardial ischemia that was driving the shock state. She was loaded with 600 mg of clopidogrel. Iliofemoral angiography was performed through the existing right femoral sheath. This demonstrated a small iliac system, the caliber of which was deemed unsuitable for delivery of a larger ventricular assist device. The sheath was upsized to 8F, and the left coronary ostium was engaged with an 8F contralateral support guiding catheter. The lesion was double wired so that both the predilation balloon and the stent could be delivered in rapid, sequential fashion over separate wires (Figure 3A). After predilation with a 2.0-mm semicompliant balloon, a 3.0×12-mm bare metal stent was deployed and postdilated with a 3.5-mm noncompliant balloon at high pressure. The patient’s vasopressor requirement immediately began to decrease. Because of the improvement, the decision was made to not pursue PCI of the right coronary artery, and she was transferred back to the cardiac intensive care unit.

The patient was successfully weaned from vasopressors over the next 72 hours, and the IABP was removed. A repeat echocardiogram showed an improvement in her ejection fraction to 42%. She was extubated on day 5 but required prompt reintubation as a result of hypoxic failure from mucous plugging. She was re-extubated on day 8 and ultimately discharged to a rehabilitation facility on day 14. She returned home 28 days after her initial presentation and returned to her baseline functional status ≈3 months after discharge. She was seen in

Table. Massachusetts Data Analysis Center In-Hospital Mortality Risk Model for Patients with STEMI or Cardiogenic Shock

<table>
<thead>
<tr>
<th>Patient Demographics and Risk Factors</th>
<th>Odds Ratio</th>
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<td>0–59</td>
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<td>Rescue PCI or PCI for unstable STEMI</td>
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<tr>
<td>Compassionate use case*</td>
<td>6.79</td>
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*PCI indicates percutaneous coronary intervention; and STEMI, ST-segment-elevation myocardial infarction.

*Compassionate use criteria include (1) extreme anatomic risk defined as an intervention involving unprotected left main with ejection fraction <35%, last remaining coronary with ejection fraction <35%, unprotected left main in the setting of STEMI or cardiogenic shock, or last remaining coronary in setting of STEMI or cardiogenic shock; (2) coma on presentation; and (3) cardiopulmonary resuscitation ongoing at the start of the procedure.

Figure 3. Left main intervention. A, An 8F guide was selected to allow both the predilation balloon (solid yellow arrow) and stent (dashed yellow arrow) to be positioned side by side near the left main ostium. After rapid predilation and balloon withdrawal into the guide, the stent was advanced quickly to the left main lesion and deployed. B, After postdilation with a 3.5-mm noncompliant balloon, the final angiographic result was excellent. Hemodynamics improved immediately.
follow-up 6 months, 1 year, and 18 months after her initial presentation without any symptoms of chest pain or heart failure. She reported enjoying time with her children and grandchildren. Unfortunately, her husband died of a myocardial infarction ≈15 months after her index admission.

Discussion

Revascularization in Cardiogenic Shock

The Should We Emergently Revascularize Occluded Arteries (SHOCK) trial published more than a decade ago established the benefit of coronary revascularization in improving outcomes in cardiogenic shock. This study randomized 302 patients with cardiogenic shock complicating acute myocardial infarction to medical therapy versus revascularization with either angioplasty or CABG. IABP was used in 86% of patients in both groups. Although 30-day mortality was not significantly different between the medical therapy and revascularization groups (56.0% versus 46.7%, respectively; \( P = 0.11 \)), revascularization improved survival at 6 months (50.3% versus 63.1%; \( P = 0.03 \)), a difference that was sustained during 6 years of long-term follow-up.\(^{15}\) Based on this study, current American College of Cardiology/American Heart Association guidelines recommend revascularization, either PCI or CABG with appropriate anatomy, in all patients presenting with ischemia-associated cardiogenic shock.\(^{7,16}\)

Although there exists an accepted beneficial role of revascularization in cardiogenic shock, there is less certainty about which mode of revascularization should be used in shock patients with surgical anatomy. Hochman et al\(^{15}\) performed a prespecified analysis of outcomes for patients receiving CABG and PCI within the SHOCK trial. Of the 128 patients in shock treated with revascularization, 81 (63.3%) underwent PCI and 47 (36.7%) received CABG. As expected, the burden of diabetes mellitus, 3-vessel, and left main disease was significantly higher in the CABG group, as the revascularization modality was selected on the basis of operator discretion, and only 13% of patients in the PCI group had significant left main disease. Although time from infarction to revascularization was significantly shorter in PCI patients (11.0 versus 19.1 hours; \( P = 0.001 \)), survival rates at 30 days and 1 year were similar in the PCI and CABG groups (30 days: 55.6% versus 57.4%, \( P = 0.86 \); 1 year: 51.9% versus 46.8%, \( P = 0.71 \)), suggesting a complementary role for both modalities in appropriately selected patients.

To better characterize outcomes in a shock population with significant left main disease, Lee et al\(^{17}\) examined the patients with left main disease enrolled in the SHOCK trial and separate SHOCK registry who were treated with revascularization. This analysis included 164 patients, with 79 and 85 receiving PCI and CABG, respectively. Survival at 30 days was significantly higher in the CABG group (54% versus 14%; \( P = 0.001 \)), even though the infarct-related artery was the left main in roughly equal proportions of patients in the PCI and CABG groups (24.5% versus 25.4%). Several caveats are worth mentioning, however. The trial protocol recommended CABG for patients with left main disease, and given that nearly half of the cohort underwent PCI, it is likely that many patients either were too ill or were deemed not to have appropriate surgical targets to fare well with open bypass surgery. Moreover, time to CABG after infarction was 3-fold longer (7.4 versus 24.3 hours; \( P < 0.01 \)) than that of PCI, raising the possibility of "survivor bias," in which the process of surviving the initial delay before CABG selects for a healthier population in the CABG group compared with the PCI group.

ST-segment–elevation myocardial infarction guidelines recommend against the treatment of non–infarct-related arteries at the time of primary PCI. Fortunately, although the right coronary artery appeared to be the culprit, this was not an ST-segment–elevation myocardial infarction presentation on the basis of ECG criteria. The decision was made to treat the left main coronary artery, believing that it was most responsible for the patient’s shock state, and successful intervention would provide the best chance of a favorable outcome. Recent studies have demonstrated added benefit in treating nonculprit arteries at the time of primary PCI in ST-segment–elevation myocardial infarction guidelines.\(^{18}\)

Ventricular Support and Cardiogenic Shock

IABP counterpulsation is commonly used in patients with cardiogenic shock, an accepted practice that is recommended (Class I) by current societal guidelines.\(^{16}\) Contemporary data, however, have not consistently supported this paradigm. A meta-analysis of randomized trials assessing the efficacy of IABP in cardiogenic shock reported that although counterpulsation favorably affects hemodynamics, it does not improve 30-day mortality.\(^{19}\) In an analysis of 18,990 IABP-supported high-risk PCI procedures from the National Cardiovascular Data Registry, of which 9,441 were performed in the setting of cardiogenic shock, increasing IABP use was not associated with a reduction in in-hospital mortality.\(^{20}\) More recently, in IABP SHOCK II, a trial of 600 patients with myocardial infarction complicated by cardiogenic shock randomized to IABP versus no IABP support, 30-day mortality was similar between groups (39.7% versus 41.3%; \( P = 0.69 \)). Timing of IABP placement did not influence outcomes either; mortality rates in the IABP arm were similar in patients who received IABP before and after revascularization (36.4% versus 36.8%, respectively; \( P = 0.96 \)).\(^{21}\) Whether novel support devices (eg, Impella) improve clinical outcomes in shock is unclear and should be the subject of future investigation. In light of such data, the practice of routine ventricular support in cardiogenic shock has been questioned, and it remains to be determined whether this recommendation will be downgraded in future guideline documents.\(^{22}\)

Current PCI Practice in the Era of Public Reporting

State-mandated public reporting of PCI outcomes is currently done in 4 states and is under consideration in many others. Proponents of public reporting contend that such transparency is informative to patients, provides incentives for quality improvement, and leads to better patient outcomes.\(^{23,24}\) However, avoidance of high-risk cases may be a natural unintended consequence of such programs,\(^{25}\) particularly in light of the widespread negative publicity that individuals and institutions may be subject to if publicly reported outcomes are
worse than expected. Joynt et al examined PCI procedures at hospitals with and without public reporting systems for PCI and reported that rates of PCI for myocardial infarction were significantly lower in states with public reporting, with differences most pronounced for patients with shock or cardiac arrest. In Massachusetts, the implementation of public reporting was associated with declines in the use of PCI for patients with acute myocardial infarction, particularly in those with shock or cardiac arrest (Figure 4). Thus, debate still exists about the net effect of public reporting systems that may improve quality of care but also drive risk aversion, potentially leading to the withholding of procedures from high-risk patients who may derive the greatest benefit.

Public reporting of hospital outcomes relies on statistical methods that attempt to capture the severity of illness of patients to adjust risk for differences in case mix between hospitals. Such methods typically estimate a ratio of the actual mortality rate of the hospital in PCI patients to its “expected” mortality rate based on the risk-adjustment methodology. Patient characteristics that are not accounted for in risk models have the potential to create biased results that falsely raise or lower the measured performance of a hospital. However, this bias occurs only in situations in which unmeasured characteristics are both prognostically important and unevenly distributed among hospitals.

In this case, the risk estimation presented to the family was based on the same prediction model that had been used to risk adjust and publicly report PCI outcomes in Massachusetts from the prior year. In-hospital mortality was estimated to be 92%, in large part because of 2 variables: the existence of cardiogenic shock and the status of the PCI as one of “compassionate use.” The compassionate use variable was created from a collaborative endeavor among interventional cardiologists, public health officials, and statisticians in Massachusetts to capture patient risk for PCI more adequately and includes presentation with coma after arrest, ongoing cardiopulmonary resuscitation, and PCI for extreme anatomic risk (such as left main intervention in the setting of cardiogenic shock). The implementation of the compassionate use variable was found to be associated with an increase in the number of patients undergoing PCI for cardiogenic shock between 2005 and 2007.

Surrogate Decision Making and Medical Futility

Medical decisions for critically ill patients often involve participation of family members entrusted with the responsibility of making decisions on behalf of the patient. Information on prognosis discussed among physicians and surrogate decision makers is often a key determinant of whether aggressive care will be pursued in the critically ill. However, a number of studies have suggested that discordance among physician and surrogate perception of prognosis is common. When such discordance exists, it is often the case that surrogates’ prognostications are more optimistic those presented by clinicians. Additionally, it is not certain that surrogates will correctly predict patients’ treatment preferences even if their perceptions of prognosis and futility are correct. A meta-analysis of nearly 20,000 patient-surrogate paired responses found that surrogates incorrectly predicted patient end-of-life treatment preferences in one third of cases. Taken together, these studies indicate that families may frequently opt to pursue more aggressive approaches to care than would have been chosen by the physician or the patient because of both an overly optimistic belief about the likelihood of the patient’s survival and an incorrect interpretation of the patient’s own desires for treatment.

Withholding procedures from high-risk patients may be appropriate in those patients for whom interventions would not be expected to change the outcome. Identifying such cases of “medical futility” is potentially fraught with challenges. Attempts to define medical futility have been made by many, including Schneiderman et al, who proposed that physicians “should regard a treatment as futile if empirical data show that the treatment has less than a 1 in 100 chance of benefiting the patient” in a qualitatively meaningful manner. Definitions such as these have been criticized on a number of grounds, including an inability of physicians to precisely define expected benefit, a lack of consensus about what threshold of benefit would be considered not worthwhile, and the perception that medical futility may be used by physicians as a “trump card” that enables withholding of treatment without patient input. The presented case is illustrative of all 3 of these challenges: The expected mortality varied widely among publicly available validated risk scores; the condition of the patient was such that reasonable physicians might have disagreed about whether the procedure was futile; and the unilateral withholding of a procedure could raise questions about whether the decision was motivated by risk aversion in response to public reporting of outcomes.

Although we have presented a single case with unique features, the elements that must be considered in such an assessment of futility are likely to be common across a diversity of clinical scenarios. They include the severity of the acute condition, the baseline comorbidity of the patient, and the likelihood of short- and long-term recovery, in addition to the patient’s previously stated preferences. In the case presented, the ostial left main lesion was very amenable to PCI, the chances of immediate procedural success were high, and the potential for rapid alleviation of global ischemia was significant. More complex disease or anatomy not suitable to PCI may have altered clinical decision making and influenced the determination of medical futility. Ultimately, however,
the method by which clinicians “draw a line in the sand” to proceed under high-risk circumstances or deem a situation medically futile is necessarily influenced not only by the unique clinical circumstances of the disease presentation and the stated or inferred values of the patient but also by the physician’s own values.

**Conclusions**

This 73-year-old patient with a history of stroke developed ventricular fibrillation followed by cardiogenic shock as a result of a critically narrowed left main coronary artery and an acutely occluded right coronary artery. Although the patient was rapidly declining in the predawn hours, the specifics of the case mandated that the physician team and family spend time discussing the technical considerations of revascularization, the presumed goals and preferences of an intubated patient, the estimation of procedural risk, and the potential for medical futility. In cases such as this, the goals of the patient may not be well understood, and the incentives to achieve them are often not completely aligned among patients, their families, and the medical team. In an era of publicly accountable, patient-centered care, this case is illustrative of the myriad challenges encountered each day in the quest to offer transparent, ethical, and effective care to critically ill patients.

**Disclosures**

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