# Diagnostic Error in the Critically Ill: Defining the Problem and Exploring Next Steps to Advance Intensive Care Unit Safety

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Critically ill patients are particularly vulnerable to being harmed by safety problems (1). In response to the modern patient safety movement, contemporary intensive care units (ICUs) worldwide are working to reduce preventable harm, such as through comprehensive unit-based safety programs (2), central line insertion checklists (3), and bundles for preventing ventilator-associated pneumonia (4). Despite progress in ICU safety, diagnostic errors remain largely unexplored and understudied in critical care. Compared with other safety problems, diagnostic errors are more difficult to identify and, due to the intricacies of the diagnostic process, are more difficult to unravel (5). There is growing momentum to understand and address diagnostic error throughout medicine, culminating in the 2015 publication of the National Academy of Science, Engineering, and Medicine's report, *Improving Diagnosis in Health Care* (henceforth "the National Academy report") (5). In this Perspective, we highlight the problem of diagnostic error in the ICU and outline areas that warrant further exploration by intensivists.

## Diagnostic Error in the Critically Ill—Frequency and Origin

Diagnostic error occurs in 5–20% of physician–patient encounters (5), with a comparable prevalence among ICU admissions and patients who die in the ICU (6–8). Diagnostic error in the critically ill has traditionally been estimated from autopsies, an accepted standard for diagnostic certainty (6). In a systematic review of autopsy studies of adult ICU patients, Winters and colleagues (6) found that 28% of autopsies identified at least one misdiagnosis, and estimated that 1 in 16 ICU deaths were due to lethal misdiagnoses. Furthermore, diagnostic errors comprise 9–12% of adverse safety events leading to ICU admission (7, 8), and the majority of these errors are deemed preventable (7). The contemporary pediatric literature contains additional compelling data. Autopsies in the pediatric ICU have found major diagnostic errors in more than 20% of patients (9). In a recent retrospective study of critically ill children, diagnostic errors were found in 12% of high-risk admissions to the pediatric ICU, with the frequency rising to almost 30% for children unexpectedly transferred from a general ward and subsequently requiring vasoactive medications or endotracheal intubation within 24 hours of ICU admission (10). An analysis of the morbidity and mortality conference at another pediatric ICU found that 21% of cases presented had diagnostic errors, and that 35% of these errors were discovered only after autopsy (11).

Despite evidence of their burden, there are significant limitations to the literature on ICU-related diagnostic errors. Autopsy studies are especially prone to bias. On one hand, autopsy studies may underestimate the true prevalence because of failure to capture many nonfatal errors. Yet autopsy is generally performed when some uncertainty exists; thus, selection bias is also likely. Winters and colleagues (6) attempted to correct for the latter by estimating the prevalence of fatal diagnostic errors at an idealized autopsy rate of 100%, but this correction only yields a rate of lethal errors. More importantly, autopsy studies do not clarify whether errors occurred before ICU admission or developed *de novo* during the course of ICU care. Other studies using retrospective chart review of ICU admissions have suffered from inadequate operational definitions and/or less rigorous methodology (7, 8).

Broadly, diagnostic errors in any setting result from cognitive failures, systems-based failures, or both. Omitting a critical part of the physical examination, misinterpreting a laboratory value, or not considering an appropriate differential diagnosis represent examples of common cognitive failures (12, 13). Systems-based failures, such as from poor coordination of care across health systems or inadequate mechanisms to convey critical results, also

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contribute to errors in the diagnostic process. Importantly, systems factors, such as an unorganized and chaotic clinical work environment, also affect cognitive processes by way of distractions and interruptions.

Often both cognitive failures and systemic factors, such as inadequate flow of information and breakdowns in communication, occur together (5).

There are numerous factors that are likely to increase the risk of diagnostic error in critically ill patients. Diagnostic errors tend to be more lethal with increased acuity of illness (14). The complexity of critical care can greatly hinder the diagnostic process as described in the National Academy report (*see* Figures 1A and 1B) (5). Similar to other chaotic and error-prone environments, such as the emergency room, patients are often actively deteriorating on arrival to the ICU, and a comprehensive diagnostic evaluation—such as chart review, collateral history-taking, or advanced imaging—may be deferred until patient stabilization. Critically ill patients are often unable to be interviewed or to participate in the physical examination, thereby limiting opportunities to gather important data. The highly complex, fast-paced practice

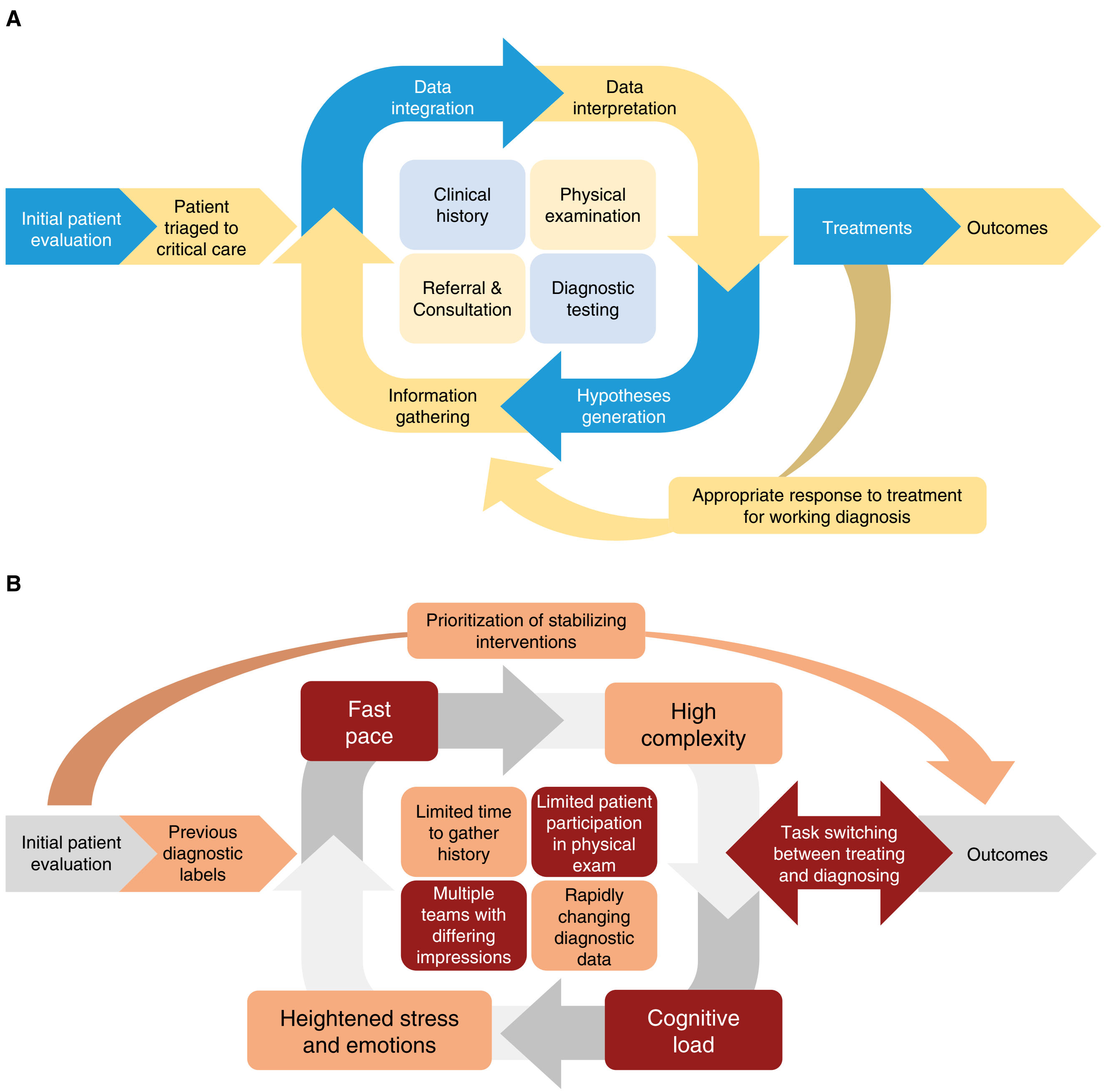


**Figure 1.** (*A*) The intensive care unit diagnostic process (adapted from Reference 5) superimposed with (*B*) the common hindrances to diagnosing critically ill patients.

environment of the ICU and rapidly changing physiology of the patient generate a constant stream of distractions and new diagnostic data points. Moreover, intensivists must simultaneously manage the taxing processes of diagnosing patients and treating physiologic abnormalities, and this constant task switching increases the risk of error (15). The Herculean tasks of synthesizing myriad data points while also "seeing the forest for the trees" further exacerbate cognitive load. Almost always, intensivists begin their diagnostic evaluation after other clinicians have already evaluated the patient and assigned tentative diagnostic labels. This diagnostic momentum can strongly bias subsequent evaluations (16), and how cases are framed in the handover from the emergency department or medical ward may perpetuate errors. In addition, clinicians practicing critical care often experience fatigue, emotional stress, and burnout (17), all of which are linked to making medical errors (18). Finally, the burdens of documentation and competing demands from other elements of high-quality ICU care, such as adherence to various protocols or best practices, may also distract from the diagnostic process.

One might speculate that intensivists have distinct advantages in the diagnostic process as well. Diagnostic resources, including imaging and access to consultants, are often prioritized to the ICU. Low patient-to-nurse ratios, well-developed multidisciplinary teams, and unique monitoring modalities enhance recognition of disease states and responses to empiric therapy. Finally, although a potential source of bias, tentative diagnoses from previous clinicians may ultimately prove correct, and preliminary steps in the patient's evaluation can narrow the range of diagnostic possibilities. Nevertheless, despite these perceived advantages, diagnostic errors continue to pose a significant risk (6–8).

## Consequences of Diagnostic Error in the Critically Ill

Diagnostic errors may result in death, permanent disability, or prolonged hospital length of stay (19); harms are likely to be amplified in the ICU setting. Beyond morbidity and mortality, diagnostic errors have a tremendous economic impact. They are the costliest mistake in settled malpractice claims (14), and they have far-reaching financial implications when considering inappropriate diagnostic studies, misguided treatments directed at incorrect diagnoses, and lost clinician time. In addition, diagnostic errors lead to psychologic consequences, such as anger and mistrust among patients and families (20). These sentiments are especially relevant to intensivists who must develop therapeutic alliances in the absence of long-standing relationships. Moreover, intensivists themselves may suffer shame or loss of confidence after making diagnostic errors, a phenomenon labeled the "second victim effect" (21).

## A Pragmatic Approach to Diagnostic Error in the ICU

Because the diagnostic process is imprecise and nonlinear, diagnostic error is inherently difficult to define and measure (5). Identifying diagnostic error within the ICU is arguably even more difficult. Critically ill patients may present actively deteriorating with highly undifferentiated signs and symptoms, so intensivists frequently forego the formal diagnostic process in favor of rapid stabilization. When deterioration outpaces even the most expeditious diagnostic evaluation, an accurate diagnosis may never be established, such as in massive pulmonary embolism or overwhelming sepsis. In addition, intensivists often join a diagnostic evaluation already in process in which diagnostic hypotheses are actively being tested.

Distinguishing the evolving natural history of illness from true missed opportunities is challenging. Accordingly, it is difficult to delineate whether patients experienced diagnostic error within the ICU environment, in their clinical course before ICU admission, or both. For example, a patient with respiratory failure who is transferred to the ICU from the medicine ward may be ultimately diagnosed with hospital-acquired pneumonia during the second day of their ICU admission. Although the hospitalist may rightfully view the ICU transfer as prompt recognition of an impending, undifferentiated crisis, the intensivist may retrospectively identify missed early warning signs that heralded severe pneumonia. Investigating these phenomena is confounded by pervasive hindsight bias, with the intensivist occupying the privileged position of knowing the outcome. Given these factors, it is unsurprising that few studies have examined nonfatal diagnostic errors in the critically ill.

The ultimate goal of detecting and measuring diagnostic errors in critical care is to advance patient safety, and measuring such errors begins with a robust operational definition. The National Academy report defined diagnostic error as "the failure to (a) establish an accurate and timely explanation of the patient's health problem(s) or (b) communicate that explanation to the patient" (5), but this definition may have only limited applicability to improving ICU safety. As noted, the diagnostic process in the ICU is highly imprecise and rapidly evolving, and incomplete explanations might be tolerated if they do not lead to harmful delays in emergency stabilization or deleterious therapeutic decisions. Therefore, we advocate for an ICU-centric approach to diagnostic error that emphasizes learning from *missed opportunities* in the diagnostic process that: *1*) stem from cognitive and/or systemic failures; and *2*) have caused or could potentially result in *preventable* harm (22). For example, few intensivists would find missed opportunities when a patient with severe acute respiratory distress syndrome is discovered to have had a stroke only after the deep sedation and neuromuscular blockade necessary for lung-protective ventilation are discontinued. Similarly, a patient who succumbs to cardiac arrest from a massive pulmonary embolism after presenting with nonspecific, atypical symptoms may have suffered a delay in diagnosis, but determining preventability of harm would prove difficult. However, there are likely to be missed opportunities to prevent harm when a febrile patient with bacteremia and cardiogenic shock does not undergo timely evaluation for endocarditis. Often though, there are no clear missed opportunities even when diagnosis is delayed, such as when a patient has a highly atypical presentation or has a rare condition that defies existing medical knowledge (5). An analytic view that focuses on systems failures and/or cognitive problems in preventable errors can better direct efforts to potential solutions.

## Intensivists' Roles in Creating Solutions

Intensivists are well positioned to identify diagnostic errors and to lead efforts to mitigate their impact. Transfer to the ICU itself can represent a seminal safety event, and can be used as a "trigger," or clue, to potential diagnostic errors in the inpatient setting (23). As such, unplanned ICU admissions are a rich data source for identifying potential diagnostic errors (24). Intensivists whose roles include internal quality review should regularly evaluate other sentinel triggers in the ICU, such as cardiopulmonary arrest or emergent procedures, for potential diagnostic errors. Ideally, the local ICU culture should also make clinicians feel comfortable using internal event reporting systems to proactively report potential diagnostic errors. Although institutional culture change may be difficult, making reporting and internal quality review an expectation could increase opportunities to capture potential diagnostic errors, including those not associated with adverse events. For example, diagnostic specialties, such as radiology and pathology, conduct routine secondary peer reviews even for cases in which there is no uncertainty or adverse outcome; conducting these reviews in the ICU would normalize such auditing.

The National Academy report also emphasized a team approach to diagnosis (5). Whether working in closed, semi-open, or open unit models, intensivists are *de facto* leaders of the diagnostic team. By collaborating across disciplines and engaging consultants, intensivists can gain valuable diagnostic insight and disperse their own cognitive load. Health care organizations should seek solutions that improve intensivists' access and communication with other diagnostic specialties, such as pathology or radiology. Intensivists themselves should maintain a leadership style that empowers bedside nurses and other members of the interdisciplinary team to partake in the diagnostic process. For example, ICU nurses gather critical collateral history from family members, thereby bridging physician–family communication. Experienced nurses often recognize when the patient's course or response to therapy does not fit the presumptive diagnosis, and may even suggest alternative diagnoses not considered by the physician team. Although there are advantages to closed ICUs, diagnostic input from previous care teams and patients' primary care physicians could also be invaluable. ICUs using a closed model could consider requiring consultation or corounding with these other teams on the first day of ICU admission—in effect creating an expanded handover.

Diagnostic feedback is recognized as critical to improving safety (5). Because intensivists often receive patients transferred from other physicians, the ICU physician could also serve to close feedback loops to referring providers. This type of ongoing quality assurance or "diagnostic auditing" has been proposed as a method to improve clinicians' diagnostic performance over time (5). Similarly, intensivists might receive feedback on their own diagnostic accuracy from peer review, as discussed previously here, or from subsequent providers, such as the ward hospitalist. To be effective, feedback would need to be presented in a blame-free fashion with actionable solutions. There is wide recognition that these methods need to be further developed with input from practicing clinicians about how to best receive the data (5). However, opening morbidity and mortality conferences and root cause analyses to multiple disciplines and fostering a collegial environment in these conferences are important first steps. Finally, increasing ICU autopsy rates—whether through improved clinician training in soliciting permission, by engaging families, or expanding use of postmortem computed tomography (i.e., "virtual autopsy" for non-forensic uses)—would likely shed light on additional diagnostic errors not recognized antemortem (5, 11).

Patient-centeredness has become a major priority in the diagnostic process, and the National Academy report offered strategies to partner with patients and their families as potential solutions to diagnostic error. Patients and family members serve as key historians and links for information sharing across fragmented care organizations, and can also strongly advocate for patient safety. Integrating families into daily ICU rounds, expanding visiting hours, and/or carving out separate time for family-centered rounds allow

**Table 1.** Key recommendations for enhancing diagnostic safety in the intensive care unit

| Domain | Specific Interventions Recommended |
|---|---|
| Enhancing recognition of potential errors | • Use of triggers, such as death in the ICU or cardiopulmonary arrest, to identify potential cases for review<br>• Routine secondary peer review of diagnostic outcomes, even for cases without adverse events |
| Increasing teamwork and patient-centeredness in the diagnostic process | • More streamlined, bidirectional communication between the intensivist and diagnostic specialties, including radiology and pathology<br>• Multidisciplinary rounds with a culture of open communication among team members<br>• Expanded family access to physicians and members of the multidisciplinary team<br>• Improved handovers from emergency departments or hospital wards and continued involvement of previous care teams, particularly for the highest-risk patients |
| Providing feedback on the diagnostic process | • Multispecialty morbidity and mortality conferences or case review conferences that espouse a blame-free culture<br>• Bidirectional reporting of diagnostic outcomes between the ICU and sources of referral (e.g., emergency room, hospital ward, another hospital)<br>• Staff training and family education to increase autopsy rates or expanded use of postmortem computed tomography (i.e., "virtual autopsy") for nonforensic uses |
| Expanding role of health information technology | • Development and use of more sophisticated EHR data scanning algorithms based on machine learning<br>• Telemedicine or other virtual access to rapid critical care consultation when indicated<br>• Using EHR functions to detect potential errors, such as by detecting substantive changes from admitting ICU diagnosis to discharge ICU diagnosis |

*Definition of abbreviations*: EHR = electronic health record; ICU = intensive care unit for greater family participation in the diagnostic process. Though ICU patients are often too ill to be their own informants, efforts to improve patient participation in data gathering, such as by minimizing sedation, could also be beneficial to the diagnostic process.

Capitalizing on advances in information technology may also provide opportunities to reduce diagnostic error (5). Many proposed enhancements to the electronic health record (EHR) are speculative, and many practicing intensivists might argue that the EHR burdens the diagnostic process as much as it lightens cognitive load. However, specific improvements to health information technology, many of which are already appearing in ICUs and hospitals, hold promise for addressing diagnostic error in the critically ill. For example, clinical decision support tools and rapid data processing from the EHR, such as "sepsis screening" tools on the wards, have become commonplace. As these systems become more sophisticated and machine learning grows (i.e., allowing computers to design detection algorithms themselves based on analysis of big datasets), they should improve specificity without sacrificing sensitivity. Telemedicine may also improve diagnostic performance in the ICU. Existing virtual electronic ICUs already expand intensivists' reach into smaller community-based hospitals and emergency departments. Though specific data are lacking on how telemedicine influences diagnostic accuracy (25), timely consultation with an expert—in this case, the remote intensivist—is a widely recommended strategy for reducing diagnostic error (5). Finally, EHRs can be leveraged to create novel triggers that automate detection of potential errors (23); examples include substantive discrepancies between the admitting ICU and discharge ICU diagnoses, or abrupt changes in medications, such as antibiotic orders entered only after a positive blood culture resulted.

A summary of these potential solutions are outlined in Table 1.

## Conclusions

The time is ripe for the critical care community to define the scope of the problem of diagnostic error in the ICU. This endeavor would require support for research using robust, contemporary, and prospectively collected data. Furthermore, we need to identify the most pervasive contributory factors that lead to diagnostic errors in the ICU. Whether researchers or educators, administrators or clinicians at the bedside, we all have a role in contributing potential solutions. In our quest for excellence in caring for the critically ill, let us make reducing diagnostic error a top priority. ■

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