

Will the Electronic Medical Record Live Up to Its Promise?

Several years ago, a colleague showed us the medical record of a patient cared for by Dr. Charles Mayo. In surprisingly legible cursive, Dr. Mayo had documented his physical exam, assessment, and care plan for the day: "Looks like appendicitis; best operate!" We had a good chuckle, secretly bemoaning the passing of days when physicians didn't have to worry about documenting the rationale for their decisions. However, the good old days left a lot to be desired: new encounters all too often relied on the vague memory of prior diagnoses and interventions, and the same diagnostic tests were repeated endlessly on every stop along the health care journey. Most doctors hadn't yet discovered the value of teamwork, and were expected to be all present and all knowing. Luckily, the electronic medical record (EMR) is about to fix these woes; or will it?

It does not take a lot of imagination to envision the future patient's room equipped with a large high-definition monitor, displaying patient- and task-tailored information in ways providers can easily assimilate. The information will trigger checklists that point out potential errors of omission and commission, identify adverse drug interactions, and adjust medication dosing, cognizant of the patient's genetic makeup. Voice-recognition devices will monitor patient-provider interactions and distill them into a succinct narrative in near real time. In addition, the information gathered and generated during every patient encounter will be assimilated and queried by supercomputers equipped with artificial intelligence, so that hypotheses about disease mechanisms and efficacy of treatments may be tested continuously in virtual, *in silico* clinical trials. Well, maybe our imagination did get a bit ahead of us, but the seeds of the required technology do already exist.

According to the most recent report (1), fewer than 2% of U.S. hospitals had fully functional EMRs in 2009. Although the first versions of computerized charts and decision support for complex interventions had been developed more than 20 years ago, their use remained restricted to the intensive care units of a single institution (2). Since then, the digital storage and display of images and laboratory data has become commonplace. However, charting of monitoring data, nursing flow-sheets, and clinical notes remain largely paper based. Even in institutions equipped with comprehensive EMRs, providers are often hesitant to embrace the new technology (3). All too often, they have to access multiple disparate systems and navigate complex interfaces to access needed information. The process is not only time consuming but also burdened by an ever-increasing amount of irrelevant data. Management decisions are often based on insufficient understanding of data and thought processes by information technologists and their medical advisors. The result is indiscriminate data presentation, information overload, and consequently, lower-than-anticipated rates of EMR use and acceptance (4). Indeed, information overload represents one of the major challenges of applied health informatics, with cognitive burden hampering treatment plan-

ning and quality of care, which leads to poor patient outcomes (5, 6). These problems are amplified in the intensive care unit setting, where the complexity of the environment and the need for rapid decision making can push the system to the brink of chaos (7, 8). Compounding this problem are poorly thought-out documentation requirements, standards, and regulations, which tend to serve reimbursement goals as opposed to efficient knowledge transfer. Considering the enormous potential for benefit and harm, it is surprising how little outcomes research has been devoted to the design and implementation of the EMR.

EMRs promise many benefits, including the politically attractive avoidance of wasteful spending. However, their key objective and selling point is enhanced quality of care and patient safety (9). Carefully developed and tested data displays (dashboards) and sophisticated decision-support tools can enhance safe patient "traffic" through the complex health care environment, not unlike the way in which a global positioning system guides drivers through busy city streets. Decision support is not a substitute for clinicians, just as global positioning systems are not a substitute for drivers. It simply helps getting to the desired destination. The ideal EMR accommodates flexible, rule-based systems that expose clinicians to the specific information that is essential for the timely and error-free completion of the task at hand (i.e., task-specific information management). For example, a critical care provider caring for a patient with a massive gastrointestinal hemorrhage needs immediate access to a relatively small number of critical data: vital signs; adequacy of vascular access; the contact numbers of the on-call endoscopist, interventional radiologist, and surgeon; historic information about liver disease, alcoholism, and the use of anticoagulant or antiplatelet medications; results of selected laboratory tests, such as hematocrit, platelet count, fibrinogen, and INR; knowledge of fluid replacement and cardiovascular management history; as well as the assessment of airway and patient preference, should endotracheal intubation become necessary. This information takes priority during initial patient evaluation, whereas other data can be accessed as needed, depending on the results of the initial evaluation.

The example underlines the point that designing an EMR that is to meet the stated objectives is far more complex than building user interfaces around databases. The process requires free and unrestricted access to real-time electronic databases (10) and encompasses a stepwise-development approach. It must begin with process modeling and a compilation of user data utilization, include the identification and mapping of key clinical patterns and rules development, and explore the best way to deliver the information. To maximize their value, "choice architects" (11) of modern EMR applications will need to consider basic principles of cognitive psychology and human factor engineering with appropriate use of desirable "defaults," intuitive user-friendly interfaces, forcing functions and timely and specific user feedback.

The initiative for "meaningful use" of EMR is boosted by the recent decision of the U.S. government to reduce waste and harm by modernizing health care information technology: "Before spending of billions creating and implementing such

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systems, careful consideration must be given to how this information will be integrated into decision making" (12). The current generation of EMR needs to be redesigned to facilitate accurate, timely, and efficient clinical decision making, and greatly enhance safe care delivery through simulation modeling, education and feedback, oversight, and competency assessment. Health care information technologies today have all the capability and the full technical potential to support the care of critically ill patients. Now it is time for psychologists, human factor engineers, and most of all the clinical research community, to come on board.

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OGNJEN GAJIC, M.D.

VITALY HERASEVICH, M.D., PH.D.

ROLF D. HUBMAYR, M.D.

*Pulmonary and Critical Care Medicine, Mayo Clinic
Rochester, Minnesota*

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The Right Ventricle in Pulmonary Hypertension From Dogma to Data

Men will die upon dogma but will not fall victim to a conclusion.

— John Henry Newman (1801–1890)

Right ventricular (RV) dysfunction and failure are harbingers of poor outcomes in pulmonary arterial hypertension (PAH). Lower cardiac index and RV ejection fraction are associated with a higher risk of death even with effective therapies (1–4). Although pioneers of pulmonary artery catheterization were intensely focused on the inextricable relationship of the right heart with the pulmonary circulation (5, 6), more recent studies have focused on the treatment of the pulmonary vascular disease in isolation. Now, more than 60 years after the publication of the first studies of pulmonary artery catheterization to interrogate RV function in patients with lung disease, there has been a reawakening of interest in the integral role the RV response plays in the clinical outcome of the patient with pulmonary vascular disease.

The determinants and management of right heart failure remain poorly studied. The only clearly effective therapy for right heart failure is diuresis, although digoxin and inotropic support are also occasionally used. Present recommendations suggest avoidance of negative inotropes, particularly β -blockers (7), which are feared to precipitate or exacerbate right heart failure. One unblinded and uncontrolled study showed that the withdrawal of nonselective β -blockers in patients with portopulmonary hypertension improved cardiac output and the distance walked in 6 minutes (8). However, the association of sympathetic activation with worse outcome in PAH (9), the adverse effects of such activation on the left ventricle (LV), and the survival benefit of β -blockade in congestive heart failure

(10, 11) have led some to question the conventional wisdom in right heart failure (12–14).

In this issue of the *Journal* (pp. 652–660), Bogaard and colleagues report on a study of carvedilol in the treatment of two rodent models of pulmonary hypertension (15). These investigators showed that carvedilol administration increased cardiac output (despite a reduction in heart rate via an increase in stroke volume), tricuspid annular plane systolic excursion, and exercise endurance in the SU5416 plus hypoxia rat model. There were similar findings in the monocrotaline animal model and (to a lesser degree) with the more β_1 selective metoprolol. Carvedilol also caused reductions in RV mass and fibrosis and preservation of the RV microvasculature, suggesting that these were adaptive changes. Interestingly, carvedilol also caused up-regulation of the fetal gene program, usually considered to be maladaptive.

The investigators have iconoclastically challenged the role of adrenergic blockade in RV failure. Strengths of this research include (1) administration of the experimental therapy after the establishment of pulmonary vascular disease, enhancing possible translation to clinical practice; (2) replication of the main findings in two animal models with two different adrenergic receptor blockers; and (3) demonstration of a benefit in terms of cardiac function, exercise endurance, and survival. Findings that require further clarification include whether carvedilol had an additional direct pulmonary vascular effect (possibly through α blockade) and whether the precise timing or duration of carvedilol administration would change the results.

What are the implications for future studies of the RV and for clinical management of RV failure? Investigations into the