Occasional Essay

From Intensive Care to Critical Care Medicine
A Historical Perspective

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The evolution of Critical Care Medicine is traced in relationship to its predecessors, namely Intensive Care and Intensive Therapy. This commentary documents the initial physical care rendered by professional nurses in hospitals of the 19th century in locations close to the nursing stations. The development of incubators for newborns and life-support devices to support ventilation and renal function or to reverse fatal arrhythmias characterized Intensive Therapy of the early 20th century. In the most recent 50 years, Critical Care evolved for comprehensive, largely electronic monitoring and automated laboratory measurements to guide intensive therapy of multiorgan failures by critical care physicians and nurse specialists, pharmacists, and respiratory therapists using multiple life-support methodologies and devices.

HISTORY DOCUMENTS THE "WHERE FROM" AND SERVES AS A BEACON OF "WHERE TO"

Efforts to trace the history of Intensive Care, Intensive Therapy, and Critical Care have pinpointed a diversity of events, and authors have credited a comparably large number of inventive individuals to whom parentage is attributed. This history has been extensively referenced and therefore is not recited in detail (1–6). Critical Care as a specialty discipline in developed countries became surprisingly rapidly recognized and formally established in the United States as a certified subspecialty in remarkably less than 20 years. However, in our view, its origins are best traced to the overlapping and presently interchangeable names of hospital units, namely Intensive Care, Intensive Therapy, and Critical Care.

The innovation of creating a separate area proximal to the nursing station for battle-injured British soldiers during the Crimean War of the 1850s, especially for watchful nursing care after major battle injuries and surgical interventions, is attributed to Florence Nightingale. This is most often cited as a beginning of Intensive Care. With the expansion of large hospital wards and a scarcity of semiprivate and private beds in the late 19th and first half of the 20th century, the most seriously ill patients were segregated in semiprivate and private beds, often under the care of special-duty nurses. As early as 1927, Dr. Walter Dandy, a student of Harvey Cushing and famed successor in his own right, sought to improve the postoperative care of neurosurgical patients. He arranged for a separate and defined site in the Johns Hopkins Hospital in Baltimore for his postoperative patients. This concept of specialized sites for care of patients in the postoperative, high-risk interval was rapidly expanded, especially during World War II, when postoperative observation and so-called shock units evolved for initial care of the severely wounded.

In each of these postoperative, postanesthesia sites, the primary emphasis was on care with lifesaving interventions based largely on vital signs, primarily by professional nurses. The nurses were trained to implement the routines established by surgeons and later by anesthesiologists during the high-risk, early postoperative interval. Although these postoperative observation units were staffed for only a portion of each day, typically up to 8 hours, the increasing durations of surgical operations and the perceived need for specialized postoperative observation and care increased in parallel with the increasing invasiveness of surgical operations. Yet, during the first half of the 20th century, except for postoperative and postanesthesia management, there was usually no special provision for severely ill medical patients.

Provisions for care of the sickest patients were also driven by economic and social priorities. Because of the increasing cost of dedicated nursing for only one or two patients, hospitals encouraged use of private-duty nursing, usually in private or semiprivate rooms, paid for by the patient or the family. Ward patients who were most severely ill, especially when there was the likelihood of early death, were routinely moved into side rooms, a "ward room" for terminal care. This minimized the adverse impact on the moderately ill ward patients who occupied as many as 40 contiguous beds (4).

The recovery units of World War II and the recovery areas of civilian hospitals until the late 1950s had little or no specialized equipment, not even the primitive monitors that came into use as part of operating room anesthesia practices during that decade. Until the 1950s, Intensive Care Units were therefore physical sites that accommodated primarily postoperative patients for special and personalized care, accommodations that were strategically and economically advantageous in an era in which much of the care was rendered in large hospital wards.

The next most often cited landmark represented Intensive Therapy Units. This era began in the 1940s in response to major advances in specific lifesaving medical technologies. These units provided devices and techniques that were invented and implemented to compensate for failure of a single organ system. Most prominent among these were methods and mechanical devices with which to secure the airway and maintain respiratory gas exchange. Tracheostomy had become a routine intervention for securing the airway long before the poliomyelitis epidemics, which were especially profound in the United States in 1948 and later in Denmark in 1952. Patients with bulbar poliomyelitis and respiratory paralysis were ventilated in

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Drinker-Shaw "iron lungs" and with chest cuirasses. When hospitals were overwhelmed by the large number of paralyzed polio victims, patients had tracheostomies and were manually ventilated by medical students. These interventions were the predecessors to out-of–operating room endotracheal intubation and mechanical ventilation. Piston ventilators, developed by Morch, were followed by the Bennett and the Bird intermittent positive pressure valves and the Emerson "pressure cooker" ventilator. In the 1960s, the Engstrom was the first commercially available ventilator that had the capability for separately controlled inspiratory and expiratory pressures and flows. Specialist anesthesiologists were responsible for artificial ventilation as an extension of their operating room skills, with instrumenting the airway and maintaining ventilation during anesthesia and neuromuscular blockade (6, 7). During the Vietnam conflict, acute respiratory distress syndrome was a major complication of battlefield trauma (8, 9), and military surgeons and anesthesiologists used the more advanced techniques of intubating the airway and using mechanical ventilation to sustain soldiers and civilians.

Several other specialty devices for treatment of single organ failures included treatment of renal failure with dialysis machines introduced by the Dutch physiologist Kolff in 1943. During the Korean War in 1952 to 1953, rat-borne Hantavirus infected soldiers and civilians, producing hemorrhagic fever. This was a major cause of renal failure. Hemodialysis was lifesaving (10). AC electrical defibrillators, which for practical purposes evolved only in the 1950s, served as primary resuscitation devices for both mobile and in-hospital coronary care. Together with transvenous cardiac pacing, these prompted the expansion of cardiac (coronary) care units. The invention of incubators for management of premature newborns is attributed to the French physician Stephane Tarnier in 1880 but was clinically implemented together with respiratory support and nutritional management in 1922 by Julius Hess. This prompted the relatively wide expansion of newborn nurseries in hospitals as the predecessor of neonatal intensive care units (11).

Each of these sites was therefore for intensive care nursing together with interventions that included devices for support of only one organ system. Currently used monitors, except for those that were physically incorporated into the single-organ life-support devices, were not yet available. This contrasted with current-day comprehensive cardiopulmonary monitoring of patients with multiorgan failures, including alarms and preparedness for multisystem interventions. Intensive Therapy therefore evolved from Intensive Care in the context of a physical site for management of a specific organ failure without comprehensive monitors or other life-support devices. Accordingly, provisions for monitoring and intervention for a diversity of immediate life-threatening diseases, and especially for patients with multiorgan failures, were lacking.

A small community hospital in New Jersey claimed in 1954 that it was the first hospital in the United States to implement a modern Intensive Care Unit. Yet, as late as 1960, this same hospital had only one prototype monitor and one AC defibrillator that served all hospital beds (12). It is to this extent that the sites for Intensive Care and later Intensive Therapy lacked not only multisystem life support but also the instrumentation for real-time monitoring, measurements, and alarms that characterize the current practices of Critical Care Medicine. In the present era, multiple hemodynamic, respiratory, and metabolic monitors are complemented by STAT laboratory measurements (13). Beginning in the late 1950s, titrated therapy was in response to cardiorespiratory and metabolic measurements that indicated life threat. The priorities of intervention were multisystem and typified by an acronym quite widely adopted by our trainees (14). The order of lifesaving priority was VIP. V was to secure Ventilation and respiratory gas exchange. The I was for Infusion, to secure adequacy of the intravascular volume. The P was for the Pump, the adequacy of cardiac output and systemic blood flows. Measurements with digital processing of data facilitated interpretation. In turn, the data prompted Intensive Therapy using multiorgan support methodologies and devices.

Hence, the third and current era of Critical Care Medicine evolved from the Intensive Care in the Nightingale era. Intensive Therapy was largely a 20th-century development in the United States and Western Europe, quite selectively in support of single organ systems for failure of ventilation or renal function and control of potentially fatal cardiac rhythms. In the late 1950s and early 1960s, the present era of Critical Care began with automated monitoring of vital signs with alarms and rapidly expanded to allow for additional and refined measurements of patient status. Initially, largely analog monitors soon gave way to current-era digital displays and alarms, with modern computer systems (14). Respiratory and hemodynamic measurements were complemented by laboratory measurements of blood gases, routine blood chemistries, and new measurements, including cardiac enzymes and blood lactate, initially in STAT laboratories and later with current multiparameter point-of-care analyzers. Based on measurements with priority alarms, the bedside clinician was therefore guided to intervene promptly with titrated therapy, such as to preclude physiological deterioration and immediate life threat.

The majority of physicians and surgeons of the 1960s and 1970s were understandably neither conversant nor comfortable with the formidable new Critical Care technology at the bedside, nor with increasingly invasive intravascular devices. Physicians and surgeons therefore had little option but to surrender or at least share responsibility for diagnosis and management of the critically ill with a new cadre of physicians, surgeons, and anesthesiologists who were the early intensivists. These were the physicians, the nursing specialists, respiratory therapists, and later, clinical pharmacists who became the critical care teams of the present day. Over the years that followed, specialists in internal medicine and especially pulmonologists, surgeons (especially trauma surgeons), and anesthesiologists were attracted to and later certified in the subspecialty in the United States. In European countries and Australia, anesthesiologists more often took the lead in mastering both the biomedicine and biotechnology of Critical Care, but intensivists and specifically pulmonary physicians now represent the majority of physician providers in the United States.

Accordingly, it was the technology, and specifically the monitors and measurements, that increasingly distinguished themselves from their predecessors Intensive Care and Intensive Therapy. They facilitate prompt bedside diagnosis and interventions in settings of multiorgan failure, such as sepsis and septic shock. In fact, these practices were first modeled by our group at the University of Southern California in Los Angeles beginning in 1959. The basic inventory of measurements included not only the conventional vital signs of the preceding era (directly measured intraarterial pressure, heart rate, respiratory frequency and regularity, and body temperature) but also central venous pressure, circulation times, and cardiac output, all complemented by results obtained in an on-site STAT laboratory (15). It was in 1959 that, contemporaneously, the first modern Critical Care Unit evolved at the University of Pittsburgh, spearheaded by the late Dr. Peter Safar. Both centers initiated full-time presence of appropriately trained Critical Care specialty physicians in the units. Both the Pittsburgh and Los Angeles units served as leaders in initiating the

first subspecialty Critical Care Medicine training programs and many of their graduates became early leaders worldwide. In the early 1960s, Dr. William Shoemaker, a student of the famed surgical physiologist, Dr. Francis Moore, spearheaded surgical critical care when he organized the first Trauma Unit at the then Cook County Hospital in Chicago.

We have come a long way since the death of George Washington in 1802, who was in the care of the most respected physicians of the day. These physicians were guided by only a minimal understanding of clinical respiratory and cardiovascular physiology and failed to agree on a tracheostomy to overcome asphyxia likely caused by epiglottitis (16). Instead, the doctors used conventional treatment, especially bloodletting, encouraged by General Washington himself. Washington's servant and his doctors removed more than one-half of General Washington's blood volume by bleeding, ending in a combined respiratory and cardiovascular death.

In citing this history, we therefore trace the evolutions of Intensive Care as a locale or site, and Intensive Therapy as single-system support and especially ventilation. The techniques of Critical Care Medicine have been extended to include not only the conventional hospital units but also emergency departments and even out-of-hospital emergency medical providers in ambulances and aircraft in which critical care monitors, measurements, and life-support devices provide care before hospital admission. Even though the three terms, Intensive Care, Intensive Therapy, and Critical Care, are still used interchangeably, in our view they trace the history of Critical Care Medicine.

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