



# The promise and the paradox of technology in the intensive care unit

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Although health-related technology encompasses the drugs, devices, procedures and organizations used in health care delivery,<sup>1</sup> in this article we focus on the devices used to care for critically ill patients. There are few settings as evocative of health technology as the intensive care unit (ICU), where technology is used to monitor physiology (e.g., the intra-arterial blood pressure catheter), to diagnose morbidity (e.g., protected specimen brush catheter) or to treat (e.g., mechanical ventilation). Some ICU technologies have combined monitoring, diagnostic and therapeutic effects (e.g., intracranial devices that transduce intracranial pressure, drain cerebrospinal fluid and record subsequent pressures). This is *the promise* of technology in the ICU. Herein lies *the paradox*: First, although the ICU is replete with technologies, and the lives of many critically ill patients are dependent upon them, few of these technologies have undergone rigorous evaluation before their dissemination. Second, when they are evaluated carefully, some technologies generally considered beneficial have the potential for harm.

The first paradox is epitomized by the pulmonary artery catheter. There is no ICU device more widely celebrated yet debated. Early trials comparing standard care with management aided by these catheters focused on understanding pathophysiology (successfully) and modifying patient outcome (unsuccessfully). Pleas for better evaluation of pulmonary artery catheters have ranged from hortatory statements pronouncing a moratorium on their use,<sup>2</sup> to more visionary calls to investigators, funding agencies and policymakers to collaborate on research promotion and guidelines development.<sup>3</sup> A recent observational study suggesting increased mortality among patients with pulmonary artery catheters<sup>4</sup> prompted rejoinders from professional associations and biotechnology boardrooms, highlighting the axiom that a diagnostic tool can only improve outcome if the therapy predicated on these diagnostic test results is itself effective. Using the pulmonary artery catheter to measure filling pressures and cardiac output, thereby targeting "supraphysiologic" oxygen delivery preoperatively, has been associated with lower mortality rates in some investigations. A large multicentre study by the Canadian Critical Care Trials Group evaluating this application of the pulmonary artery catheter in high-risk surgical patients is nearing completion (Dr. Dean Sandham, Foothills Provincial General Hospital, Calgary: personal communication, 1999).

An illustrative example of the second paradox is the mechanical ventilator. This quintessential ICU technology undeniably delays death in many patients with respiratory

failure and does not require a randomized trial to prove it. However, experimental studies have shown that mechanical ventilation may cause physiologic and structural lung damage. Specific ventilation strategies in patients with the acute respiratory distress syndrome have been associated with barotrauma, biotrauma,<sup>5</sup> organ dysfunction<sup>6</sup> and increased mortality. Strategies to minimize ventilator-associated lung injury include low tidal volume ventilation targeted to 6 mL/kg, which has also been associated with significantly lower mortality than higher tidal volumes.<sup>7</sup>

Many ICU technologies are disseminated before they are evaluated. However, when they are evaluated, it can be difficult to demonstrate that they make a difference.<sup>8</sup> Some technologies prolong life while not improving (or possibly worsening) the quality of life. Without rigorous technology assessment, useless, cost-ineffective or even harmful technologies may be introduced. In 1990 the Ontario Ministry of Health convened a Critical Care Technology Working Group, which recommended more technology evaluation, education and delivery of research to purchasers and users.<sup>9</sup> Since then, hemodynamic monitoring,<sup>10</sup> noninvasive blood-gas monitoring,<sup>11</sup> bronchoalveolar lavage<sup>12</sup> and gastric tonometry<sup>13</sup> have been evaluated using a diagnostic technology assessment framework evaluating how technology works in the laboratory, its range of uses and diagnostic accuracy, and its impact on clinicians' practices and patients' outcomes.<sup>14</sup> Canadian investigators have also demonstrated how information furnished by bronchoscopy increases diagnostic confidence,<sup>15</sup> explored safety of noninvasive positive-pressure ventilation<sup>16</sup> and conducted randomized trials evaluating pressure-limited ventilation.<sup>17</sup>

The mantra of technology assessment during the next millennium should champion rigour and relevance from bench to bedside, but also beyond, through health services research. Public awareness of the sparse clinical outcomes data associated with many costly ICU technologies portends well for more comprehensive evaluation in the future.

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