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Outcomes of Intensive Care: Medical Benefits and Cost Effectiveness

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DIFFICULTIES IN ASSESSING EFFECTIVENESS

Evaluating the effectiveness of the care provided in the general adult intensive care unit (ICU) presents a number of problems. Unfortunately, it is difficult to separate the intensity of the care from the setting in which it is provided **(97,98),** and therefore, to know whether the same care would have been equally effective whether it was provided in an ICU or in a general hospital floor.

Theoretically, at least, intensive therapy could be provided on regular medical floors (120). In fact, there are institutional differences about who is treated in ICUs and for how long (142). Moreover, the level and style of intensive care for similar health problems differ significantly among ICUs (67). These differences have developed because of the particular circumstances of individual hospitals, rather than because established criteria were available **(247).**

For some complex medical problems, many physicians feel that the necessary care can only be provided in an ICU (65). In the late 1960s and 1970s, admission to an ICU became routine for a number of medical problems, despite the lack of evidence that ICU care improved outcome. There have been no prospective clinical trials in which patients with similar problems were randomly allocated to two groups, one of which was treated in an ICU while the other received intensive care outside the ICU (98,222). There is general agreement that such randomized studies would be unethical (262,279), and it is felt that for many problems, treatment in an ICU is necessary if a patient is to have a chance of survival (50).

Since, as noted, randomized clinical trials of ICUs are considered by many to be unethical, most ICU outcome studies have been historical controls and pre-ICU / post-ICU designs (166). These types of studies, however, have been seriously flawed by the absence of acceptable criteria for stratifying ICU patients by diagnosis and severity of illness to assure comparability of patient populations between different ICUs and in the same ICU over time (226,248,281).

In the coronary care unit (CCU), for example, it is felt that patients suffering myocardial infarction should be stratified into clinically coherent subpopulations based on the type of myocardial infarction suffered in order to assess outcome properly (28). The problem of stratification is especially complicated in the ICU, because patients often have multiple diagnoses, which make categorization difficult (16,265), and because their severity of illness varies (136).

There are other practical problems in conducting research on ICU outcome, including:

1. the fact that any individual institution will have a relatively small number of patients in any clinical subset;
2. the lack of a standard format for collecting data;
3. the difficult yin obtaining informed consent from ICU patients in need of immediate, lifesaving intervention **(176);** and
4. the difficulties in conducting studies that follow patients after their discharge from the hospital.

In short, because of the absence of an accepted classification scheme for stratifying ICU patients into accepted subpopulations and because prospective clinical trials have not been performed, very little is known about the effectiveness of the ICU as a distinct, discrete technology. Investigators who report on changes in ICU mortality rates or lengths of stay can only speculate on whether their patient populations have changed over time **(227,248).**

Finally, while the primary measure for assessing the effectiveness of ICUs is patient outcome, it should be recognized that the ICU as a discrete unit within the hospital may be a focus for education and research activities which have positive "trickle down" effects on care for non-ICU patients (55,86,97). At the same time, however, the presence of ICUS may adversely affect the quality of nursing care on the regular medical and surgical floors (25,136). As difficult as it is to measure the effectiveness of ICU treatment for patients in the ICU, it is nearly impossible to assess objectively the benefits or drawbacks of the ICU for the hospital as a whole.

CLINICAL OUTCOMES OF ICU CARE

Because of the varied case-mix in ICUs, it is impossible to generalize about whether ICU care improves outcome. The NIH consensus panel, which was asked to assess this issue, concluded that evidence of the benefit of ICU care was unequivocal for a portion of the heterogeneous ICU patient population (176). The NIH panel identified different outcomes for three categories of patients (176):

> First is the patient with acute reversible disease for whom the probability of survival without ICU intervention is low, but the survival probability with such interventions is high. Common clinical examples include the patient with acute reversible respiratory failure due to drug overdose, or with cardiac conduction disturbances resulting in cardiovascular collapse but amenable to pacemaker therapy. Because survival for many of these patients without such life-support interventions is uncommon, the observed high survival rates constitute unequivocal evidence of reduced mortality for this category of ICU patients. These patients clearly benefit from ICU care.
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> Another group consists of patients with a low probability of survival without intensive care whose probability of survival with intensive care may be higher—but the potential benefit is not as clear. Clinical examples include patients with septic or cardiogenic shock. The weight of clinical opinion is that ICUs reduce mortality for many of these patients, though this conviction is supported only by uncontrolled or poorly controlled studies. Often these studies do not allow one to distinguish between ICU effectiveness and / or differences in cointerventions that do not require the ICU.
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> A third category is patients admitted to the ICU, not because they are critically ill, but because they are at **risk** of becoming critically ill. The purposes of intensive care in these instances are to prevent a serious complication or to allow a prompt response to any complication that may occur. It is presumed that the prompt response to a potentially fatal complication made possible by continuous monitoring plus the concentration of specialized personnel in the ICU increases the probability of a favorable outcome. The risk of complication may be high (as in the patient with an acute myocardial infarction and complex ventricular ectopy) or low (as in the patient with myocardial infarction suspected because of chest pain in the absence of electrocardiographic abnormalities). Also, the differences in probability of a favorable outcome following a complication inside rather than outside the ICU may be large (as in the patient with postcraniotomy intracranial bleeding) or small (as in the patient with gastrointestinal bleeding). The strength of evidence supporting the effectiveness of the ICU varies with the probability of a complication and with the difference in expected outcome inside and outside the ICU. When the risk of complication is high and the potential gain large, a decrease in mortality is likely. Similarly, when the risk is low and the potential gain small, an observable decrease in mortality is unlikely. These patients are not likely to benefit from ICU care.

The differences in outcomes of ICU care by diagnosis has been demonstrated in all studies that have looked at the issue, from the earliest studies (17) to the most recent (248). Table 9 gives examples of specific retrospective outcome studies on the effect of ICU care for certain illnesses. (Note that contradictory findings are sometimes found for the same condition.) In general, conditions which respond well to ICU care are reversible illnesses without significant underlying chronic illness (e.g., respiratory arrests as a result of drug overdoses, major trauma, reversible neuromuscular diseases such as Guillain-Barre Syndrome, and diabetic ketoacidosis) (198,214). Conditions which generally do not respond well are exacer-

Table 9.—Retrospective Outcome Studies of ICU Care

Study	Condition
A. ***Studies showing definite reduction in mortality for condltlon:***	
Petty (1975). .	Respiratory failure treated with ventilators
Rogers.	Respiratory failure treated with ventilators
Bates	Status asthmatics and emphysema
Drake	Non-hemorrhagic strokes
Skidmore . . .	Postoperative trauma patients
Feller.	Severe burns
B. Studies showing no reduction in mortality for condition:	
Pitner.	Strokes
Piper	Drug overdose
Jennet	Head injuries with coma
Casali	Postoperative acute renal failure
Griner	Pulmonary edema
Hook	Pneumococcal bacteremia

NOTE Studies are cited in the Reference section

SOURCE Off Ice of Technology Assessment

bations of chronic conditions for which there has been no definitive treatment (e.g., cirrhosis with gastrointestinal hemorrhaging, and advanced cancer).

Most studies have looked at mortality in the ICU or in the hospital as a measure of the efficacy of ICU care. However, for some physiologic conditions, such as cardiac arrest, ICU care may be lifesaving in the short term but may not affect the ultimate course of the underlying illness (174,214). Indeed, in some instances, patients with severe underlying illnesses, such as terminal cancer and cystic fibrosis, have not been offered ICU care because of the dismal prognosis associated with the underlying illness (58,110,252,253).

Investigators have only recently begun to look at posthospital survival. As might be expected, the ability to follow patients for 6 months or longer after their ICU stay depends to a great extent on the population being studied. In general, chronically ill and medical patients are more likely than acutely ill and surgical patients to die shortly after discharge from the hospital (29,34,50,129, 146,174,175,178,248) .

FUNCTIONAL OUTCOME

Different investigators have used varying measures of functional status to gauge outcomes other than mortality. These measurements have been subjective and depend to a large extent on the patient's prehospital functional status. For patients with a chronic disability, posthospital functional status is almost never better than their prehospital functional status (34,40,146), although improvement has occasionally been found (29).

Surgical patients suffering an acute injury or illness have a reasonable chance of returning to a normal functional status (54,178). In a followup study, Cullen reported that the l-year mortality rate was similar to the rate in a previous study of similarly critically ill patients, but that the patients' quality of life as measured by the number of patients who were fully recovered or returned to full productivity was significantly improved (54,56). This finding suggests that Outcome COme measures other than survival should also be examined when determining effectiveness of ICU care.

CHARACTERISTICS OF ICU NONSURVIVORS

As noted above, certain diseases and conditions are associated with particularly high ICU mortality rates. Underlying disease is probably the most significant single predictor of outcome of ICU care (54,139). Other factors, including age and severity of illness, are important as well.

Age

A number of investigators have looked at the association of age and mortality in ICUS. Most have found a direct relationship between increasing age above 65 and hospital mortality (54,107,

116,178,214,248). In addition, for medical patients in particular, some have found that patients 70 and over who leave the hospital have very high posthospital mortality rates (29,174,248,249). Others, however, have found either a small or no association between age and survival (40,50,76, 165,265).

When an attempt is made to control for chronic health status in a multivariate logistic regression analysis, age has been found to remain a reliable independent predictor of mortality **(268).** This finding suggests that age is not simply a surrogate for chronic health status. Fedullo (76), on the other hand, suggests that with the passage of time, elderly patients have already gone through a process of selection, and therefore "healthy" elderly patients are as able as younger patients to survive an acute major illness.

Severity of Illness

Vanholder **(265)** found that ICU survivors had an average of 3.13 major diagnoses whereas nonsurvivors had 6.09 diagnoses. LeGall (146) found a strong positive correlation between the number of organ system failures and the likelihood of not surviving a stay in an ICU. In a number of settings, the George Washington University ICU Research group in Washington, DC (143) has tested an acute severity-of-illness measure based primarily on the deviation from normal of certain clinical and laboratory measurements. Using their scoring system, they found a direct relationship between acute severity of illness and ICU mortality and concluded that acute physiologic derangement (i.e., acute severity of illness) is second only to the underlying disease as a risk factor of hospital mortality (139). Less sophisticated severity-of-illness classification systems have consistently demonstrated a positive relationship between increasing severity of illness and likelihood of mortality (51,178).

Resource Use

In comparing resource use of ICU nonsurvivors to survivors, it is necessary to look at the patient's entire hospitalization, not just the stay in the ICU. In a number of studies from different types of hospitals, 25 to 40 percent of ICU patients who died in the hospital did so after they were transferred from the ICU to the regular medical floor (see table 5 in ch. 4). Presumably, many of these non-ICU deaths were anticipated and represented the transfer of "hopeless" patients out of the ICU.

It is now recognized that a significant number of deaths in the ICU occur after "no resuscitation" orders have been written. In two large medical centers, as many as 40 to 70 percent of ICU deaths occurred under these circumstances (9,96). In a large community hospital, 19 percent of ICU nonsurvivors had no hope of recovery and were in the ICU solely for terminal care (165). In short, a substantial portion of ICU care for nonsurvivors occurs after hope of recovery has been abandoned.

Some nonsurvivors have very short and some have very long ICU stays. Pessi (178) found that one-third of surgical ICU nonsurvivors died within 2 days and 80 percent died within 10 days of ICU admission. More recently, Cromwell (49) found that while 20 percent of ICU nonsurvivors died within 3 days of ICU admission, 10 percent died after 2 months in the ICU. **On average, nonsurvivors stay in the ICU about 1.5 to 2 times longer than survivors** (42,48,76,248)

In 1973, Civetta (42) first described the inverse relationship between ICU charges and survival. Since then, whenever it has been examined, the same relationship has been found—ICU **nonsurvivors accumulate up to two times more hospital charges than survivors** (40,49,61). Byrick (29) found the same correlation in Canada when he considered actual ICU costs rather than charges. Furthermore, nonsurvivors have incurred proportionately higher charges for ancillary services (e.g., laboratory tests, X-rays, and blood) than survivors (61,76). Only Parno (175), in a study involving a large community hospital, found no substantial difference in ICU charges between survivors and nonsurvivors.

The inverse relationship between charges and survival is not as simple as it might first appear, however. Detsky (61) looked at the relationship between charges and patients assigned to various subjective prognostic categories. He found the highest per capita charges in two groups: survivors who initially had been thought to have a poor chance of survival, and nonsurvivors who had initially been felt to have the best chance of survival. Predicted nonsurvivors who died and predicted survivors who lived consumed fewer resources. The two groups with highest charges would logically be the ones who might benefit the most from intensive medical care.

In another study utilizing a severity-of-illness measure, Scheffler (214) found a nonlinear, U-shaped relationship between the use of resources available in the ICU and the probability of survival. The first segment—45 percent of patients and 19 percent of therapeutic interventions-exhibited an overall decrease in the probability of death as therapy increased. The second segment, found at the bend of the curve, showed little correlation between probability of death and resource use. However, in the third segment, the rising portion of the U-shaped curve, there was an overall increase in the probability of death as resource use increased. This last segment represented only 9 percent of the ICU population, but those patients consumed as much as **30** to 40 percent of the ICU resources. Thus, many patients, even the most seriously ill, may benefit from additional ICU resources applied to their care. While, in retrospect, some resources may prove to have been "wasted" in the sense that individuals did not survive despite consuming these ICU resources, it is clear that many patients do benefit from increased use of ICU resources. The patients who will benefit from additional ICU resources cannot currently be identified ahead of time with any certainty.

DISTRIBUTION OF ICU COSTS AMONG PATIENTS

The data demonstrate that a small percentage of the ICU patient population consumes a substantial proportion of total ICU resources. Cromwell's group (49) found that 1 percent of all ICU patients incurred 10 percent of hospital charges, and 5 percent of ICU patients incurred 25 percent of the charges. In Chassin's ICU study (40), 7.4 percent of the patients incurred 31 percent of the charges, and 17 percent of patients incurred so percent of the charges. The 7.4 percent subgroup averaged $63,000 in charges in 1977 dollars. In general, the high cost subgroup was broadly representative of the total ICU patient population in terms of age, diagnosis, and other patient characteristics. Similarly, Parno (175) found that 18 percent of the ICU population in his hospital generated half of the ICU charges.

In addition, it is likely that within the ICU, there is substantial cross-subsidization of charges. As noted in chapter 4, ICU populations include patients who are there primarily to be observed and monitored for the development of complications as well as patients who are receiving complex life-sustaining therapy. The nurse-to-patient ratio can vary from 1:4 or 1:5 for patients with cardiac arrhythmias to 1:1 or greater for the sickest patients (176). While a portion of fixed direct costs and allocated indirect costs should be distributed evenly among all patients, the ICU charge structure does not reflect the substantial differences in variable labor costs between patients.

The Therapeutic Intervention Scoring System (TISS) (53,130) is a relative value scale which reduces most of the tasks commonly performed within an ICU to 75 items which are assigned varying weights. It has been used as a direct measure of the use of labor in the ICU. Wagner (270) found that patients recuperating from coronary bypass surgery utilized 2.5 times more TISS points per day than ICU patients recovering from brain surgery.

The difference in labor resource use appears to be even greater for other types of patients (51,54). The distribution of TISS points suggests that all ICU patients receive a minimum amount of treatment beyond that provided on the regular wards (67). The data also suggest, however, that even if indirect and fixed ICU costs are distributed evenly among all patients, perhaps 50 percent of actual ICU resource costs—particularly labor costs—vary dramatically among patients.

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As noted earlier, the sickest ICU patients incur substantially more total hospital charges than those who are relatively less sick. Yet, the actual cost differences between these two groups is even greater. Under the new Medicare payment system, which pays a fixed price per diagnosis regardless of actual cost of the treatment provided, hospitals 'may become more aware of the highly disproportionate share of ICU resources consumed by the most severely ill, long-term ICU patients (see ch. 6).

MONITORED PATIENTS

Increased attention has been paid recently to ICU patients who do not receive active intensive therapy but rather are monitored and observed for the development of potentially fatal complications which must be responded to promptly (176). Progress has been made in identifying the characteristics of coronary patients who do not routinely require coronary intensive care (85,90,141, 189,190), and in recognizing CCU patients who can be discharged to the general floor after 24 hours rather than the usual 3 days (163). Similarly, national and regional data on intensive care for patients with burns suggest that a substantial number of patients suffering relatively minor burns do not benefit from treatment in an intensive bum unit but receive it nevertheless (78,151).

Researchers at George Washington University (269) found that 513 of 1,148 admissions (45 percent) to a mixed medical-surgical ICU in a teaching hospital could be considered "monitoring only" patients. Using a multivariate logistic regression analysis of several variables, including a severity-of-illness measure, they found that 154 patients **(13** percent of the total ICU patient population) had less than a 5-percent predicted risk of requiring active intensive therapy. For those patients, the authors felt that the risks of iatrogenic illness' might outweigh the benefits of ICU monitoring. In fact, only of the 154 low-risk patients actually received intensive therapy, and in no case did those patients require therapy for an immediately life-endangering condition. After updating their data base and looking at preliminary data from other university hospitals, the authors concluded that all ICUs have significant proportions of predictably low-risk, monitor admissions (141). The conclusions were supported in a recent study by Fineberg that looked at patients with a risk of myocardial infarction that is low, but not low enough for home care to be desirable (about 5 percent). He calculated that admission to an intermediate care unit, rather than a CCU, was highly cost effective (79).

Others who have studied monitored patients are not as sanguine about the ability to predict low risk. In a coronary care-oriented ICU, Thibault (248) found that 1 of 10 patients admitted for careful monitoring subsequently required a major ICU intervention. Using primarily subjective criteria, he could not predict which of the monitored patients would do well.

Teplick, et al. (246), studied patients routinely admitted to a surgical ICU after uneventful, major surgery of various types. Using a fairly conservative definition of benefit, the authors found that overall, 33 percent of the patients benefited medically from an overnight stay in the ICU. There was a broad range in the percentage of patients who benefited from ICU care across types of surgery, from 44 percent of patients who had vascular surgery to no patients who had anterior cervical Iaminectomies. A number of the unanticipated complications were immediately life-threatening. Furthermore, using both a preoperative risk assessment and an evaluation of intraoperative problems, the authors were unable to identify the patients within each surgical category who were more likely than others to develop serious postoperative problems.

Another study of the same ICU, however, found that less than 1 percent of patients routinely admitted overnight to the ICU for certain other surgical conditions suffered significant adverse postoperative effects (220). These contrasting findings demonstrate the importance of stratifying even the monitored ICU patients in order to determine

'An iatrogenic illness is an illness that results from clinical therapy rather than from the patient's disease.

which subgroups of monitor patients do well without routine admission to the ICU.

Attention has also been focused recently on patients who may be discharged from the ICU prematurely. Schwartz (220) found that 15 percent of patients electively discharged from the ICU, and 23 percent of patients transferred out of the ICU because of lack of space, suffered a significant adverse effect on the surgical floor. Adverse effects included death, return to the ICU, or residence in hospital 1 month after completion of the study. The researchers also found that approximately one-third of patients undergoing abdominal vascular surgery developed serious respiratory and/or circulatory conditions after discharge from the ICU. They did not speculate on whether outcomes for these patients would have been different had the complications occurred in the ICU.

In a retrospective chart review, Franklin (82) noted that 62 percent of readmission to a mixed ICU might have benefited if they had not been discharged from the ICU initially. The authors did not indicate whether the patients readmitted to the ICU differed in any predictable manner from patients who did not need to be readmitted. Nor did the study address how many lives were lost because of early discharge. Mulley (163), who recommended identification of low-risk patients for early transfer from the ICU, acknowledged that 2 percent of the low-risk group had major complications during their stay in the ICU that would have occurred after transfer if an early transfer policy had been in effect.

By stratifying ICU-monitored patients, it may be possible to reduce or eliminate ICU stays for some patients with a low risk of resulting adverse effects. This risk may, in fact, be lower than the risk of iatrogenic ICU illness for some patients. At the same time, other moderately sick ICU patients are probably discharged too soon or not admitted to the ICU at all because of lack of bed space or recognition that the patients are at risk for serious complications. As a result, they suffer avoidable adverse health effects.

Work is *only* now beginning on attempts to predict which ICU discharge patients are most likely to suffer adverse effects on the regular medical or surgical floor.

ADVERSE OUTCOMES OF ICU CARE

Iatrogenic Illness

The possibility that the adverse effects of ICU care may outweigh the potential benefits for some patients is being increasingly recognized (176,275). However, the rates of iatrogenic illness and other untoward physical and psychological reactions to ICU care are not known with any precision (176).

As with the problems of measuring the positive effects of ICU care, it is difficult to distinguish between the negative effects that occur among critically ill patients regardless of location and those that are specific to the ICU.

An iatrogenic illness is any illness or other harmful occurrence that results from a diagnostic procedure or therapy that is not a natural consequence of the patient's diseases (239). The major iatrogenic complications that result from prolonged ICU care include nosocomial infections (defined below), stress-induced gastrointestinal bleeding, alterations of consciousness associated with metabolic disorders, coagulation disorders associated with multiple transfusions and infection, drug interactions, complications of intravascular catheterization, complications of prolonged endotracheal and nasogastric incubation, and sleep disorders and psychoses (41,275). Some of these complications, such as drug interactions and bleeding, would likely occur in seriously ill patients regardless of location. Nosocomial infections and various psychological reactions are often a result of the ICU itself.

Recently, Steel found that 36 percent of patients on the medical service of a university teaching hospital had an iatrogenic illness (239). In 9 percent of the cases, the incident was life-threatening or produced considerable disability. In 2 percent of the cases, the iatrogenic illness was believed to have contributed to the death of the patient. The authors did not specify which problems specifically occurred within the CCU or ICU section of the medical service. Nevertheless, a number of the complications came from drugs, such as lidocaine, and procedures, such as Swan-Ganz catheterization, that are, for the most part, only used in ICUs.

In a different teaching hospital, Abramson (3) identified 145 reports of significant adverse occurrences in 4,720 ICU admissions during a 4-year period. Ninety-two of these incidents were felt to be the result of human error, and 53 were equipment malfunctions. However, 43 of the 92 incidents linked to human error involved equipment, mostly mechanical ventilators. Thus, about two-thirds of the adverse events involved the technically complex equipment used in ICUs. The incidence of equipment-related adverse occurrences would probably be much higher if the equipment and the staff operating it were dispersed throughout the hospital (208). On the other hand, ICU technology may sometimes be used unnecessarily for less sick patients, producing some incidence of avoidable iatrogenic illness (198). As noted in chapter 7, the ICU milieu provides a bias to the use of technology, which at times may be of only marginal benefit and can produce adverse reactions (242).

Finally, it is clear that the sophisticated care provided in the ICU requires skilled nurses and other technicians. Adverse effects in ICUs have been particularly noted during periods of nursing shortages (3,136). The ICU environment produces "technology-oriented" treatment protocols (100), and physicians are less apt to tailor therapy based on the specific skills of the nurse and technicians on duty or on the particular nurse-to-patient ratios during a particular shift. In other words, certain ICU monitoring and therapy protocols may work well under ideal circumstances but may be particularly subject to human and mechanical error under less favorable circumstances.

Nosocomial Infections

Nosocomial infections are infections occurring during hospitalization that were not present, and not incubating, at the time of hospital admission **(117).** All patients in an ICU are at increased risk of developing nosocomial infections (117). The rate of significant nosocomial infection in an ICU is about 20 percent, or three to four times that of a patient on a general ward (63,173). This increased rate stems in part from unalterable factors, including the severity of the underlying illness; the greater use of invasive procedures; and the greater use of prior antibiotic therapy, which may predispose a patient to a superimposed infection (63,117,192). However, at least part of the increased rate of ICU infection is due to cross-infection between very sick patients in the confined area of the ICU (63,204). Nosocomial infection "outbreaks" in ICUs are not uncommon (63). Bacterial infections may be spread directly from one person to another, often via personnel, or may require an intermediate reservoir, such as respirator nebulizers or tubing (117). While difficult to estimate precisely, the costs of nosocomial infections in terms of increased morbidity, mortality, and hospital charges are undoubtedly substantial (108).

Psychological Reactions

There is a substantial body of literature on the psychological reactions of patients in ICUs. It appears that the frequency of psychiatric syndromes is considerably less in a CCU, where patients are relatively stable, than in an ICU, where seriously ill patients suffer organic impairments of cerebral, renal, and pulmonary function (104,131,156).

The so-called "intensive care syndrome" **(156)** described a "madness," or acute delirium, that had originally been seen in the postoperative recovery room (168). However, many psychiatric syndromes have been noted, from acute anxiety, fear, and sustained tension to agitated depression and acute delirium (132).

The unique environment of the ICU has been graphically implicated as a cause of the varied and often dramatic psychological reactions:

> Immobilized, weak, inhibited from moving by a network of wires and tubes which connect every orifice in his body with bottles and machines, he lies watching the light pattern move from left to right on the monitor, disappear, then start again. He listens to the suction of the draining apparatus, the on and off of the pulmonary respirator, the hissing sound of the steam from the vaporized oxygen; steam which sometimes clouds his vision in the tent. He adds his own fantasies to this bewildering environment. Fear and tension mount . . . . In the ICU, the lights are on constantly, and there is little or no change in the level or type of sensory input. The activity, in spite of its decrease toward early morning, remains high. Hours and days merge and blend. Privacy is almost impossible. The patient is exposed; his most private acts become public. . . . Strangers control the machines. Their authority is absolute. In this seemingly irrational environment, he is deprived of any volitional control. He becomes an object rather than a participant in the struggle for life (62).

Sleep deprivation, sensory deprivation, sensory overload, medications, and various emotional factors related to coping with serious illness have been cited as causes for ICU psychiatric syndromes (38,104,131,145).

Given the dramatic behavioral responses to ICU care, it is remarkable that most patients remember very little about the "terror in the ICU" (216). In surveys taken both shortly after transfer out of the ICU and many months later, ICU patients generally remember few details of their stay (24,29, 115,127,162,216). Whether due to the serious nature of the underlying illnesses (104,127), the lack of sleep, which produces general fogginess (24,127), or a powerful psychological defense mechanism of denial called "psychoplegia" (104, 216,217), survivors of ICU care generally do not carry unique psychological scars of their ICU experience.

COST-EFFECTIVENESS ANALYSIS OF ADULT INTENSIVE CARE

Cost-effectiveness analysis (CEA) is intended primarily to measure and compare the costs of different ways of arriving at similar outcomes (256). This type of analysis has not been done for ICUs, because it is considered unethical to deny ICU care for most ICU patients (see ch. 6). The few "before ICU/after ICU" studies focused on relatively small ICU subpopulations and are clearly dated (99,183).

For the low-risk monitored patient, it may be ethically permissible to compare ICU observation with non-ICU observation to determine the cost effectiveness of ICU care. Both Mulley (163) and Wagner (269) have projected cost savings that would be generated by more selective admission and earlier discharge policies. Using conservative economic assumptions, Mulley found that a more selective policy would result in a 6-percent reduction in ICU charges. Similarly, Wagner estimated a 4-percent reduction in total ICU days with earlier discharge of low-risk patients. Neither author accounted for the possibility that earlier transfer from the unit might either increase or, conceivably, decrease the rate of major complications, which, in turn, would affect costs (163). Fineberg estimated that for patients with about a 5-percent probability of having sustained a myocardial infarction, admission to a CCU would cost $2.04 million per life saved and $139, ooo per year of life saved, as compared to care in an intermediate care unit (79). Teplick (246) concluded that routine overnight ICU admission for postoperative patients at an additional cost of $3oo would reduce overall patient costs if only 13 of the 88 routinely admitted patients in their study who benefited from the ICU were prevented from becoming critically ill.

Another factor in considering the overall cost effectiveness of earlier discharges of low-risk ICU patients is the fact that the costs of caring for these patients on the regular floors would increase, mostly because of the need for additional nursing, probably from private duty nurses (97,220). There might also be a need for additional monitoring equipment on the regular floors. Finally, projecting savings based on charges probably over-estimates the savings from early discharge of low-risk patients because of the cross-subsidization that is reflected in the ICU charges (see ch. 6).

Attempts have been made to assess average charges necessary to achieve one survivor for various subpopulations of ICU patients. For example, Parno (175) found that hospital charges in 1978 dollars for a survivor alive 2 years after discharge averaged $15,000, with a range of $1,650 for drug overdose patients to $46,000 for renal medical patients. In a population of the most critically ill surgical ICU patients, Cullen (50) found that in 1977-78 dollars, it required $71,000 in hospital charges to achieve a survivor alive 1 year after hospital discharge. Neither additional post-hospitalization expenses nor physician charges were included in this estimate. For the category of illness that includes gastrointestinal bleeding, cirrhosis, and portal hypertension, Cullen found that it cost $260,000 to achieve one survivor.

An interesting variation on this approach is to look at "life-years" saved (134). The method is not a true cost-benefit analysis (CBA), however, since CBA requires that benefits be assigned a monetary value in order to provide a direct comparison of the costs and benefits of a particular technology (256). Assigning monetary values to the varied and controversial outcomes of the ICU has not been done. Theoretically, the life-years saved method could be extended into CBA. Recognizing that longevity is generally considered a benefit, Bendixen used the life-year saved model to view the cost of ICU care in relation to predicted remaining lifespan. He used the following equation:

$$\text{cost} = \frac{\text{(cost per day)} \times \text{(duration of stay)}}{\text{(survival fraction)} \times \text{(predicted remaining lifespan)}}$$

This approach assumes not only that survival is a benefit, but also that survival value is a multiple of survival time, i.e., that 2 years of survival has twice the value of 1 year of survival. The approach theoretically permits one to weigh the factors of a patient's age and the prognosis associated with chronic disease. The formula, however, does not discount the future value of costs and benefits into present dollars; in essence, it overstates the importance of predicted remaining lifespan (256).

The unavailability of disease-adjusted actuarial data for diagnostic subgroups makes prediction of life expectancy for chronic diseases inexact (215). ICU survival fraction and predicted remaining lifespan are the major determinants of cost effectiveness according to this formula. Using this approach in 1977, Bendixen estimated a cost-per-year saved of $84 for barbiturate overdose and $180,000 for hepatorenal failure.

When better estimates of life expectancy for patients with chronic illnesses become available, this cost-effectiveness approach may be more useful. Nevertheless, application of this approach documents the importance of the underlying disease process and the patient's age in determining the cost effectiveness of ICU care (215). The formula currently does not permit quantitative consideration of quality of life, which is obviously important for patients with debilitating chronic illnesses (18). Methods for adjusting life-years saved for quality of life have been attempted (213), but have been criticized as representing "bad science" and for ignoring considerations of justice and equity (7).