

A Definition of Irreversible Coma

Report of the Ad Hoc Committee of the Harvard Medical School
to Examine the Definition of Brain Death

Our primary purpose is to define irreversible coma as a new criterion for death. There are two reasons why there is need for a definition: (1) Improvements in resuscitative and supportive measures have led to increased efforts to save those who are desperately injured. Sometimes these efforts have only partial success so that the result is an individual whose heart continues to beat but whose brain is irreversibly damaged. The burden is great on patients who suffer permanent loss of intellect, on their families, on the hospitals, and on those in need of hospital beds already occupied by these comatose patients. (2) Obsolete criteria for the definition of death can lead to controversy in obtaining organs for transplantation.

Irreversible coma has many causes, but *we are concerned here only with those comatose individuals who have no discernible central nervous system activity*. If the characteristics can be defined in satisfactory terms, translatable into action—and we believe this is possible—then several problems will either disappear or will become more readily soluble.

More than medical problems are present. There are moral, ethical, religious, and legal issues. Adequate definition here will prepare the way for better insight into all of these matters as well as for better law than is currently applicable.

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Characteristics of Irreversible Coma

An organ, brain or other, that no longer functions and has no possibility of functioning again is for all practical purposes dead. Our first problem is to determine the characteristics of a *permanently nonfunctioning brain*.

A patient in this state appears to be in deep coma. The condition can be satisfactorily diagnosed by points 1, 2, and 3 to follow. The electroencephalogram (point 4) provides confirmatory data, and when available it should be utilized. In situations where for one reason or another electroencephalographic monitoring is not available, the absence of cerebral function has to be determined by purely clinical signs, to be described, or by absence of circulation as judged by standstill of blood in the retinal vessels, or by absence of cardiac activity.

1. *Unreceptivity and Unresponsivity*.—There is a total unawareness to externally applied stimuli and inner need and complete unresponsiveness—our definition of irreversible coma. Even the most intensely painful stimuli evoke no vocal or other response, not even a groan, withdrawal of a limb, or quickening of respiration.

2. *No Movements or Breathing*.—Observations covering a period of at least one hour by physicians is adequate to satisfy the criteria of no spontaneous muscular movements or spontaneous respiration or response to stimuli such as pain, touch, sound, or light. After the patient is on a mechanical respirator, the total absence of spontaneous breathing may be established by turning off the respirator for three minutes and observing whether there is any effort on the part of the subject to breathe

spontaneously. (The respirator may be turned off for this time provided that at the start of the trial period the patient's carbon dioxide tension is within the normal range, and provided also that the patient had been breathing room air for at least 10 minutes prior to the trial.)

3. *No reflexes.*—Irreversible coma with abolition of central nervous system activity is evidenced in part by the absence of elicitable reflexes. The pupil will be fixed and dilated and will not respond to a direct source of bright light. Since the establishment of a fixed, dilated pupil is clear-cut in clinical practice, there should be no uncertainty as to its presence. Ocular movement (to head turning and to irrigation of the ears with ice water) and blinking are absent. There is no evidence of postural activity (decerebrate or other). Swallowing, yawning, vocalization are in abeyance. Corneal and pharyngeal reflexes are absent.

As a rule the stretch of tendon reflexes cannot be elicited; ie, tapping the tendons of the biceps, triceps, and pronator muscles, quadriceps and gastrocnemius muscles with the reflex hammer elicits no contraction of the respective muscles. Plantar or noxious stimulation gives no response.

4. *Flat Electroencephalogram.*—Of great confirmatory value is the flat or isoelectric EEG. We must assume that the electrodes have been properly applied, that the apparatus is functioning normally, and that the personnel in charge is competent. We consider it prudent to have one channel of the apparatus used for an electrocardiogram. This channel will monitor the ECG so that, if it appears in the electroencephalographic leads because of high resistance, it can be readily identified. It also establishes the presence of the active heart in the absence of the EEG. We recommend that another channel be used for a noncephalic lead. This will pick up space-borne or vibration-borne artifacts and identify them. The simplest form of such a monitoring noncephalic electrode has two leads over the dorsum of the hand, preferably the right hand, so the ECG will be minimal or absent. Since one of the requirements of this state is that there be no muscle activity, these two dorsal hand electrodes will not be bothered by muscle artifact. The apparatus should be run at standard gains $10\mu\text{V}/\text{mm}$, $50\mu\text{V}/5\text{ mm}$. Also it should be isoelectric at double this standard gain which is $5\mu\text{V}/\text{mm}$ or $25\mu\text{V}/5\text{ mm}$. At least ten full minutes of recording are desirable, but twice that would be better.

It is also suggested that the gains at some point be opened to their full amplitude for a brief period (5 to 100 seconds) to see what is going on. Usually in an intensive care unit artifacts will dominate the picture, but these are readily identifiable. There shall be no electroencephalographic response to noise or to pinch.

All of the above tests shall be repeated at least 24 hours later with no change.

The validity of such data as indications of irreversible cerebral damage depends on the exclusion

of two conditions: hypothermia (temperature below 90 F [32.2 C] or central nervous system depressants, such as barbiturates.

Other Procedures

The patient's condition can be determined only by a physician. When the patient is hopelessly damaged as defined above, the family and all colleagues who have participated in major decisions concerning the patient, and all nurses involved, should be so informed. Death is to be declared and *then* the respirator turned off. The decision to do this and the responsibility for it are to be taken by the physician-in-charge, in consultation with one or more physicians who have been directly involved in the case. It is unsound and undesirable to force the family to make the decision.

Legal Commentary

The legal system of the United States is greatly in need of the kind of analysis and recommendations for medical procedures in cases of irreversible brain damage as described. At present, the law of the United States, in all 50 states and in the federal courts, treats the question of human death as a question of fact to be decided in every case. When any doubt exists, the courts seek medical expert testimony concerning the time of death of the particular individual involved. However, the law makes the assumption that the medical criteria for determining death are settled and not in doubt among physicians. Furthermore, the law assumes that the traditional method among physicians for determination of death is to ascertain the absence of all vital signs. To this extent, *Black's Law Dictionary* (fourth edition, 1951) defines death as

The cessation of life; the ceasing to exist; defined by physicians as a total stoppage of the circulation of the blood, and a cessation of the animal and vital functions consequent thereupon, such as respiration, pulsation, etc [italics added].

In the few modern court decisions involving a definition of death, the courts have used the concept of the total cessation of all vital signs. Two cases are worthy of examination. Both involved the issue of which one of two persons died first.

In *Thomas vs Anderson*, (96 Cal App 2d 371, 211 P 2d 478) a California District Court of Appeal in 1950 said, "In the instant case the question as to which of the two men died first was a question of fact for the determination of the trial court . . ."

The appellate court cited and quoted in full the definition of death from *Black's Law Dictionary* and concluded, ". . . death occurs precisely when life ceases and does not occur until the heart stops beating and respiration ends. Death is not a continuous event and is an event that takes place at a precise time."

The other case is *Smith vs Smith* (229 Ark, 579, 317 SW 2d 275) decided in 1958 by the Supreme Court of Arkansas. In this case the two people were husband and wife involved in an auto accident.

The husband was found dead at the scene of the accident. The wife was taken to the hospital unconscious. It is alleged that she "remained in coma due to brain injury" and died at the hospital 17 days later. The petitioner in court tried to argue that the two people died simultaneously. The judge writing the opinion said the petition contained a "quite unusual and unique allegation." It was quoted as follows:

That the said Hugh Smith and his wife, Lucy Coleman Smith, were in an automobile accident on the 19th day of April, 1957, said accident being instantly fatal to each of them at the same time, although the doctors maintained a vain hope of survival and made every effort to revive and resuscitate said Lucy Coleman Smith until May 6th, 1957, when it was finally determined by the attending physicians that their hope of resuscitation and possible restoration of human life to the said Lucy Coleman Smith was entirely vain, and

That as a matter of modern medical science, your petitioner alleges and states, and will offer the Court competent proof that the said Hugh Smith, deceased, and said Lucy Coleman Smith, deceased, lost their power to will at the same instant, and that their demise as earthly human beings occurred at the same time in said automobile accident, neither of them ever regaining any consciousness whatsoever.

The court dismissed the petition as a *matter of law*. The court quoted *Black's* definition of death and concluded,

Admittedly, this condition did not exist, and as a matter of fact, it would be too much of a strain of credulity for us to believe any evidence offered to the effect that Mrs. Smith was dead, scientifically or otherwise, unless the conditions set out in the definition existed.

Later in the opinion the court said, "Likewise, we take judicial notice that one breathing, though unconscious, is not dead."

"Judicial notice" of this definition of death means that the court did not consider that definition open to serious controversy; it considered the question as settled in responsible scientific and medical circles. The judge thus makes proof of uncontroverted facts unnecessary so as to prevent prolonging the trial with unnecessary proof and also to prevent fraud being committed upon the court by quasi "scientists" being called into court to controvert settled scientific principles at a price. Here, the Arkansas Supreme Court considered the definition of death to be a settled, scientific, biological fact. It refused to consider the plaintiff's offer of evidence that "modern medical science" might say otherwise. In simplified form, the above is the state of the law in the United States concerning the definition of death.

In this report, however, we suggest that responsible medical opinion is ready to adopt new criteria for pronouncing death to have occurred in an individual sustaining irreversible coma as a result of permanent brain damage. If this position is adopted by the medical community, it can form the basis for change in the current legal concept of death. No statutory change in the law should be necessary since the law treats this question essentially as one

of fact to be determined by physicians. The only circumstance in which it would be necessary that legislation be offered in the various states to define "death" by law would be in the event that great controversy were engendered surrounding the subject and physicians were unable to agree on the new medical criteria.

It is recommended as a part of these procedures that judgment of the existence of these criteria is solely a medical issue. It is suggested that the physician in charge of the patient consult with one or more other physicians directly involved in the case before the patient is declared dead on the basis of these criteria. In this way, the responsibility is shared over a wider range of medical opinion, thus providing an important degree of protection against later questions which might be raised about the particular case. It is further suggested that the decision to declare the person dead, and then to turn off the respirator, be made by physicians not involved in any later effort to transplant organs or tissue from the deceased individual. This is advisable in order to avoid any appearance of self-interest by the physicians involved.

It should be emphasized that we recommend the patient be declared dead before any effort is made to take him off a respirator, if he is then on a respirator. This declaration should not be delayed until he has been taken off the respirator and all artificially stimulated signs have ceased. The reason for this recommendation is that in our judgment it will provide a greater degree of legal protection to those involved. Otherwise, the physicians would be turning off the respirator on a person who is, under the present strict, technical application of law, still alive.

Comment

Irreversible coma can have various causes: cardiac arrest; asphyxia with respiratory arrest; massive brain damage; intracranial lesions, neoplastic or vascular. It can be produced by other encephalopathic states such as the metabolic derangements associated, for example, with uremia. Respiratory failure and impaired circulation underlie all of these conditions. They result in hypoxia and ischemia of the brain.

From ancient times down to the recent past it was clear that, when the respiration and heart stopped, the brain would die in a few minutes; so the obvious criterion of no heart beat as synonymous with death was sufficiently accurate. In those times the heart was considered to be the central organ of the body; it is not surprising that its failure marked the onset of death. This is no longer valid when modern resuscitative and supportive measures are used. These improved activities can now restore "life" as judged by the ancient standards of persistent respiration and continuing heart beat. This can be the case even when there is not the remotest possibility of an individual recovering consciousness following massive brain damage. In

other situations "life" can be maintained only by means of artificial respiration and electrical stimulation of the heart beat, or in temporarily by-passing the heart, or, in conjunction with these things, reducing with cold the body's oxygen requirement.

In an address, "The Prolongation of Life," (1957),¹ Pope Pius XII raised many questions; some conclusions stand out: (1) In a deeply unconscious individual vital functions may be maintained over a prolonged period only by extraordinary means. Verification of the moment of death can be determined, if at all, only by a physician. Some have suggested that the moment of death is the moment when irreparable and overwhelming brain damage occurs. Pius XII acknowledged that it is not "within the competence of the Church" to determine this. (2) It is incumbent on the physician to take all reasonable, ordinary means of restoring the spontaneous vital functions and consciousness, and to employ such extraordinary means as are available to him to this end. It is not obligatory, however, to continue to use extraordinary means indefinitely in hopeless cases. "But normally one is held to use only ordinary means—according to circumstances of persons, places, times, and cultures—that is to say, means that do not involve any grave burden for oneself or another." It is the church's view that a time comes when resuscitative efforts should stop and death be unopposed.

Summary

The neurological impairment to which the terms "brain death syndrome" and "irreversible coma" have become attached indicates diffuse disease. Function is abolished at cerebral, brain-stem, and often spinal levels. This should be evident in all cases from clinical examination alone. Cerebral,

cortical, and thalamic involvement are indicated by a complete absence of receptivity of all forms of sensory stimulation and a lack of response to stimuli and to inner need. The term "coma" is used to designate this state of unreceptivity and unresponsivity. But there is always coincident paralysis of brain-stem and basal ganglionic mechanisms as manifested by an abolition of all postural reflexes, including induced decerebrate postures; a complete paralysis of respiration; widely dilated, fixed pupils; paralysis of ocular movements; swallowing; phonation; face and tongue muscles. Involvement of spinal cord, which is less constant, is reflected usually in loss of tendon reflex and all flexor withdrawal or nocifensive reflexes. Of the brain-stem-spinal mechanisms which are conserved for a time, the vasomotor reflexes are the most persistent, and they are responsible in part for the paradoxical state of retained cardiovascular function, which is to some extent independent of nervous control, in the face of widespread disorder of cerebrum, brain stem, and spinal cord.

Neurological assessment gains in reliability if the aforementioned neurological signs persist over a period of time, with the additional safeguards that there is no accompanying hypothermia or evidence of drug intoxication. If either of the latter two conditions exist, interpretation of the neurological state should await the return of body temperature to normal level and elimination of the intoxicating agent. Under any other circumstances, repeated examinations over a period of 24 hours or longer should be required in order to obtain evidence of the irreversibility of the condition.

Reference

1. Pius XII: The Prolongation of Life, *Pope Speaks* 4:393-398 (No. 4) 1958.

18TH CENTURY DENTIST.—Pierre Fauchard (1678-1761), born in Brittany, France, in 1728 published his *le Chirurgien-Dentiste*, a book which made dentistry a profession. Today, his illustrated treatise still remains an inspiration to modern dentists.

On the cover page, Fauchard describes the book as "a treatise on the teeth in which is seen the means used to keep them clean and healthy, of beautifying them, or repairing their loss, and remedies for their disease and those of the gums, and for accidents which may befall the other parts in their vicinity."

Fauchard was the first to use the orthodontal procedure in the treatment of malocclusion. He also was the inventor of many prosthetic devices. In 1746, he gave the first account of pyorrhea alveolaris, usually called Riggs disease after the American dentist, John M. Riggs (1810-1885), who in 1870 reported a method of treatment.

Where Fauchard obtained his scientific education is not known. In 1693, he was an apprentice to the French Navy surgeon-major. Perhaps that was where he received some knowledge which subsequently was augmented by his own studies. He practiced in Nantes, Rennes, and Angers before going to Paris in 1717.

An international gathering of dentists was held in Paris in July 1961 to commemorate the 200th anniversary of Fauchard's death. French postal authorities honored the occasion with the issuance of a postage stamp bearing his portrait and the cover of his book.—Mirt, J.A., "Medical Pathfinders on Postage Stamps."

