

1 Historical Aspects of the Diagnosis 2 of Death

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4 Abstract

5 Nowadays, concepts such as transplantation and brain death are part of our
6 lives. Every day thousands of patients are saved by artificial ventilatory
7 support in sophisticated critical care units, and it is common to hear about
8 kidney, lung, heart, or liver transplantation. However, a great deal of
9 research and development were needed to make organ transplantation possible
10 and to get where we are now. One of the most influential factors was
11 the change in the diagnostic criteria of death, from the classical cardio-
12 respiratory failure to brain death criteria. This was the decisive step that
13 gave theoretical and ethical support to the extraction of organs from
14 patients whose vital cardiorespiratory functions were irreversibly lost but
15 artificially maintained. As we can see, the diagnosis of death and the trans-
16 plantation of organs are closely related matters. Here, we review the his-
17 torical aspects of this relationship, divided into two main periods: from
18 ancient times to the beginning of the twentieth century and from the early
19 twentieth century to the present.

20 Introduction

21 In an era in which members of society hear every
22 day about space flight—considering whether
23 there is water on the moon or if it is possible to

live on Mars—concepts such as transplantation 24
and brain death could seem trivial. Nowadays, it 25
is common to hear about kidney, heart, lung, or 26
liver transplantation, modern medicine miracles 27
that allow the recovery of hundreds of persons. 28
Every day, thousands of patients are saved by 29
artificial ventilatory support in sophisticated crit- 30
ical care units; it is possible that every one of us 31
may one day depend on a mechanical ventilator, 32
as these devices are essential for general anesthe- 33
sia. However, the dramatic advances in medi- 34
cine—with organ transplantation being one of its 35
major achievements—and the changes that have 36
taken place in the diagnostic criteria of death are 37

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not trivial at all. The diagnosis of death has been a matter of controversy since ancient times, and this discussion remains alive today [1, 2].

A great deal of research was needed to make organ transplantation possible, and several developments had to take place for us to get to where we are now. These include advances in surgical techniques and immunology; the change in death criteria (cardiorespiratory and brain death), as well as ethical issues. All these factors made transplantation possible as we know it today.

The diagnosis of death and the transplantation of organs are closely related matters, and here we will review the historical aspects of this relationship. This chapter is divided into two main historical periods—from ancient times to the beginning of the twentieth century and from the early twentieth century to the present.

The Diagnosis of Death: From Ancient Times to the Beginning of the Twentieth Century

Ancient Cultures and Death

From the beginning of civilization, human beings have confronted death. Through time, the notion of death has evolved from a mythical–magical concept to a more complex and comprehensive one. As evidenced by mortuary artifact remains, ancient cultures believed in the continuity of life after death [3]. Different cultures developed the concept of *soul*, representing the part of the being that endures and transcends death. Both Egyptians and Greeks believed that the soul was divine in nature and, for this reason, was immortal. Regarding this concept, questions such as “where was the soul?” were asked. For ancient cultures, the soul was considered to be located in the heart, thus this organ was considered the source of vital energy and its derivatives, such as thinking and emotion [4]. Therefore, the confirmation of death was based on arrest of heart function, verifiable by the absence of pulse and breathing [5]. However, there were some dissident opinions, like that of the Greek philosopher

Alcmaedon, for whom the soul was located in the brain [6]. During the fifth century BC, an unbridgeable gulf emerged between the “cardio-centrists,” who located the soul in the heart, and the “encephalocentrists,” who located the soul in the brain.

The Diagnosis of Death: Cardiorespiratory Death Criteria

In the fifth century BC, Hippocrates stated that, although the diagnosis of death was not specifically the task of the physician, doctors had to be able to give a good estimate of when death would happen. Even though a lack of pulse and breathing were irrefutable signs of death, since Galen’s time there has been concern of conditions that could mimic death. Therefore, people started to take precautions to avoid burying somebody alive. To solve this dilemma, the solution was to delay the burial to be sure that the person was not only apparently dead, but really dead. However, as Pernick posits, with the devastating arrival of the Black Death in Europe in the year 1348, a delay from the moment of death until the burial became extremely difficult, if not impossible; people worried not only about the pestilence but also of being buried alive [7]. This was the period in which the physician acquired a new role—as a judge who confirmed the fact of death. Since then, physicians have had the responsibility and authority to distinguish between real and apparent death, based on physical signs, a role that in a more sophisticated way is still carried out today. Multiple tests and criteria to diagnose death were developed and, in some periods, 27 major signs and dozens of minor signs were used to certify death [8]. This unceasing search for reliable signs of death was enhanced not only just because of fear of premature burial but also because advances in physiology allowed the possibility of resuscitation—perhaps the final test of death. If a person showed signs of death, he had to be submitted to resuscitation maneuvers, and death could only be certified after the failure of these efforts [5].

As stated by Cooper et al., the earliest reference to artificial breathing is in the Old Testament, in the book of Kings, when the prophet Elisha restored the life of a boy through a technique that included placing his mouth on the mouth of the child [9]. In the second half of the eighteenth century, humane societies were created to resuscitate the apparently dead and occupied an important place in society. For example, the London Humane Society printed pocket cards with rules for resuscitation, awarding prizes for those who made successful rescues. The articles and treatises written by the members of these societies contained reflections on the uncertainty of the signs of death and the value of life. Mortuaries were created to prevent premature burial. In the mortuary, the corpse could be left to putrefaction, but in a hygienic environment [8]. The humane society movement spread around the world, bringing a hope never seen before, namely that death could be defeated by resuscitation techniques. Along with these techniques, during the nineteenth century several tools were developed to assist resuscitation—endotracheal cannulae, laryngoscopes, and orotracheal tubes. Attempts to develop “artificial lungs” were reported in 1921 by the surgeon Claude Beck, who was the first to use the “pulmotor” in trying to recover a patient who suddenly expired during an operation [9].

In summary, from ancient times to the first half of the twentieth century, the diagnosis of death was exclusively based on cardiorespiratory criteria. However, substantial technical advances took place that helped certify death, prevent premature burial, and restore life whenever this was possible.

The Diagnosis of Death: From the Beginning of the Twentieth Century to Present

Despite immense progress in the fields of surgery and immunology, organ transplantation would not have developed as it has done without a change in the diagnostic criteria of death, from the classical cardiorespiratory to that of brain death.

Critical Care Medical Units and the “Iron Lung”

The modern era of mechanical ventilation began in the 1920s. During this decade, Drinker conducted experiments for developing an artificial ventilation apparatus, with the aim of providing patients suffering from the respiratory paralysis of poliomyelitis with the “opportunity to recover normal breathing by maintaining artificial respiration over a period of hours or even days” [10]. Drinker developed the first practical mechanical ventilator, a tank in which the patient was placed with the head protruding, subsequently to be known as the iron lung. During the same period, Thunberg developed a respiratory assistance device called the “barospirator.” With these advances, the principle of assisted ventilation was established.

During the polio epidemic of the early 1950s, the iron lung served a major role in respiratory management, helping to save hundreds of lives. However, the shortage of iron lungs during the height of the epidemic led to more widespread use of tracheostomy and manual ventilation of patients, a method previously considered appropriate only in the operating room [11]. In Copenhagen in 1952, Ibsen was the first to use tracheotomy just below the larynx, with insertion of a rubber-cuffed tube into the trachea, a method useful in patients with impairment of swallowing and reduced ventilation. Some believe the history of intensive therapy started with the poliomyelitis epidemic in Copenhagen in 1952 [12].

Following widespread immunization against poliomyelitis, which almost wiped out the disease in the Western world, the focus of mechanical ventilation shifted. Patients requiring ventilation increasingly became those with respiratory failure on the basis of pulmonary parenchymal disease rather than individuals unable to breathe because of inadequate neuromuscular function. Advances in endotracheal intubation and the development of more reliable positive-pressure machines led to the widespread application of mechanical ventilation. Moreover, the introduction of blood gas electrodes in the 1960s made possible the rapid and rational control of oxygenation and monitoring of acid–base balance [11].

The Diagnosis of Death: Cardiorespiratory Versus Brain Death Criteria

In the 1950s, medical intervention for those with respiratory failure was considered a “resuscitation” technique, and the results obtained motivated the extensive use of artificial ventilators in patients with diseases other than poliomyelitis, including those in coma. Unfortunately, in other patients, cardiopulmonary arrest resulted in irreversible brain damage. This state was described as *coma dépassé* [13]. Along with scientific and technical advances, new questions were asked and new challenges arose. Ventilatory support did not reliably restore patients to self-sufficiency or to consciousness; the demand for intensive care unit beds outstripped the supply so that there were more patients needing ventilatory support than the health system could afford. Finally, transplantation of solid organs, such as liver and heart, were in their initial stages and this field of medicine required precise criteria on which to declare the death of the potential donor and yet avoid the loss of adequate organ function. A discussion on the definition of death took place as never before. An example of this was the allocution of Pope Pius XII called “*The Prolongation of Life*,” which established that the pronouncement of death was not the province of the church, but the responsibility of the physician: “It remains for the doctor [...] to give a clear and precise definition of death and the moment of death of a patient who passes away in a state of unconsciousness” [14, 15].

In 1968, the Harvard Ad Hoc Committee was formed to define the criteria of brain death. The committee stated that irreversible coma was equal to death [16]. In the USA, the legislative complement to this definition of death was the congressional passage of the Uniform Anatomical Gift Act (1968), which made it legal to donate a deceased person’s organs and tissues for transplantation [17].

Consequently, brain death criteria led to a general reappraisal of the meaning of death. Prior to medical intensive care, there was only one criterion of death—cessation of respiration and

circulation, or cessation of cardiopulmonary function. Alternative criteria, based on the cessation of brain function, were proposed. Today, death can be diagnosed in two ways, depending on whether or not the patient is being mechanically ventilated. In nonartificially ventilated patients, physicians evaluate the irreversible absence of heart beat and breathing to declare death. In patients who are mechanically ventilated, validated neurological tests are used to assure irreversible absence of brain (brainstem) function. The criteria for brain death are based principally on findings from the clinical examination (coma, apnea, absence of brainstem reflexes, and motor responses); confirmatory laboratory tests are only required when specific components of the clinical tests cannot be reliably evaluated [18]. Such ancillary diagnostic studies include electroencephalography, somatosensory evoked potentials, cerebral angiography, transcranial doppler sonography, and radionuclide cerebral imaging, e.g., single-photon emission computed tomography (SPECT) and positron emission tomography (PET) [1, 19].

Conclusions

Transplantation techniques have been developing for several centuries; archaeological records include antecedents from civilizations as diverse as Hindu, Egyptian, Greek, and Roman, but the major advances took place in the second half of the twentieth century. These were closely associated with advances in various fields of medicine, including surgical techniques of transplantation, artificial means for supporting body functions, such as mechanical ventilation and renal dialysis, and improved immunosuppressive therapy. However, one of the most influential factors was not directly related to scientific advances but was a change in the diagnostic criteria of death—from the classical cardiorespiratory failure to brain death. This was a decisive step that gave theoretical and ethical support to the extraction of organs from patients whose vital cardiorespiratory functions were irreversibly lost but artificially maintained.

References

1. Bacigalupo F, Huerta D, Montefusco-Siegmund R. The debate about death: an imperishable discussion? *Biol Res.* 2007;40:523–34.
2. Serani-Merlo A. The vitality of death discussions: comments on Bacigalupo et al., ‘The debate about death: an imperishable discussion?’. *Biol Res.* 2007;40:535–7.
3. Magner L. *A history of medicine*. 2nd ed. Boca Raton: Taylor & Francis; 2005.
4. Santoro G, Wood MD, Merlo L, Anastasi GP, Tomasello F, Germanò A. The anatomic location of the soul from the heart, through the brain, to the whole body, and beyond: a journey through Western history, science, and philosophy. *Neurosurgery.* 2009;65:633–43.
5. Dagli FT, Kaufman R. Clarifying the discussion on brain death. *J Med Philos.* 2001;26:503–25.
6. Crivellato E, Ribatti D. Soul, mind, brain: Greek philosophy and the birth of neuroscience. *Brain Res Bull.* 2007;71(4):327–36.
7. Pernick MS. Back from the grave: recurring controversies over defining and diagnosing death in history. In: Zaner RM, editor. *Death: beyond whole brain criteria*. Dordrecht: Kluwer Academic; 1988. p. 17–74.
8. Alexander M. The rigid embrace of the narrow house: premature burial and the signs of death. *Hastings Cent Rep.* 1980;10:25–31.
9. Cooper JA, Cooper JD, Cooper JM. Cardiopulmonary resuscitation: history, current practice, and future direction. *Circulation.* 2006;114:2839–49.
10. Drinker P, McKhann CF. The use of a new apparatus for the prolonged administration of artificial respiration. I. A fatal case of poliomyelitis. *JAMA.* 1929;92:1658–60.
11. Chen K, Sternbach GL, Fromm Jr RE, Varon J. Mechanical ventilation: past and present. *J Emerg Med.* 1998;16:453–60.
12. Gilbertson AA. Before intensive therapy? *J R Soc Med.* 1995;88:459–63.
13. Mollaret P, Goulon M. The depassed coma (preliminary memoir). *Rev Neurol (Paris).* 1959;101:3–15.
14. Pius XII The prolongation of life. (November 24, 1957) *The Pope Speaks.* 4. 1958;4:396–8.
15. Reiser SJ, Dyck AJ, Curran WJ, editors. *Ethics in medicine—historical perspectives and contemporary concerns*. Cambridge: MIT Press; 1977.
16. Ad Hoc Committee of the Harvard Medical School. A definition of irreversible coma. Report of the Ad Hoc Committee of the Harvard Medical School to examine the definition of brain death. *JAMA.* 1968;205:337–40.
17. Linden PK. History of solid organ transplantation and organ donation. *Crit Care Clin.* 2009;25:165–84.
18. Practice parameters for determining brain death in adults (summary statement). The Quality Standards Subcommittee of the American Academy of Neurology. *Neurology.* 1995;45:1012–4.
19. Heran MK, Heran NS, Shemie SD. A review of ancillary tests in evaluating brain death. *Can J Neurol Sci.* 2008;35:409–19.

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