

ORIGINAL ARTICLE

Death, dying and donation: organ transplantation and the diagnosis of death

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Refusal of organ donation is common, and becoming more frequent. In Australia refusal by families occurred in 56% of cases in 1995 in New South Wales, and had risen to 82% in 1999, becoming the most important determinant of the country's very low organ donation rate (8.9/million in 1999).

Leading causes of refusal, identified in many studies, include the lack of understanding by families of brain death and its implications, and subsequent reluctance to relegate the body to purely instrumental status. It is an interesting paradox that surveys of the public continue to show considerable support for organ donation programmes—in theory we will, in practice we won't (and don't).

In this paper we propose that the Australian community may, for good reason, distrust the concept of and criteria for "whole brain death", and the equation of this new concept with death of the human being. We suggest that irreversible loss of circulation should be reinstated as the major defining characteristic of death, but that brain-dead, heart-beating entities remain suitable organ donors despite being alive by this criterion. This presents a major challenge to the "dead donor rule", and would require review of current transplantation legislation. Brain dead entities are suitable donors because of irreversible loss of personhood, accurately and robustly defined by the current brain stem criteria.

Even the dead are not terminally ill any more.¹

Sonja migrated to Australia as a young woman, married here and raised five children. Now 50 years old, she has worked hard in the family milk bar, and has paid little attention to her health. Last evening she complained of a headache, and shortly after became unconscious. She was brought to hospital by ambulance, and admitted to intensive care, where she was put on a mechanical ventilator. It's now midnight, and the intensive care unit specialist is explaining to Sonja's husband Fehmi, in a room crowded with sobbing men and women, that Sonja has had a massive brain haemorrhage, as a result of which her brain is dead. And so Sonja is dead, though her heart is still beating due to life support systems. She asks: "Did Sonja ever discuss organ donation?"

The terms "life" and "death" are necessary for many aspects of society. Definitions of death are required to define murder and manslaughter, to allow wills to be read, to allow burial or cremation, and to allow grieving to commence. In this paper we will critically examine one specific function of the term "death"—death as a prerequisite for donation of vital organs for transplantation.

In the 1970s and 80s, the concept of "brain death" was proposed as one means by which all of the requirements for a definition of death could be reconciled. Brain death is now widely accepted in Western countries. According to Truog:

At a practical level, [the concept of brain death] has been successful in delineating widely accepted ethical and legal boundaries for the procurement of vital organs for transplantation. Despite this success, however, there have been persistent concerns over whether the concept is theoretically coherent and internally consistent. Indeed, some have concluded that the concept is fundamentally flawed and that it represents only a "superficial and fragile consensus".²

In this paper we do not dispute the fact that people *correctly* diagnosed with brain death never recover, as the evidence on

this point is clear that they do not. (Reported cases of "recovery" in adults invariably reflect misapplication of brain death criteria or inadequate testing conditions leading to incorrect diagnosis rather than "recovery from death".³) We do maintain, however, that the concepts that underlie brain death are not biologically plausible, may be unacceptable to the community at large and are inconsistent with the present legal approaches. Organ donation is a socially valuable process, however the current law appears to be out of step with what is actually happening (or current practice is out of step with the law).

THE ORIGINS OF BRAIN DEATH

The term "brain death" was introduced in 1965 following a report of renal transplantation from a heart-beating but "brain-dead" donor,⁴ and was defined formally in 1968 in the report of the Ad Hoc Committee of the Harvard Medical School.⁵ In 1981 the Report of the Medical Consultants on the Diagnosis of Death to the US President's Commission recommended that the criteria for diagnosis of brain death should be seen as synonymous with the definition of death of the organism as a whole.⁶

Since the publication of this report, clinicians have come to recognise that the essential physiological component of brain death is the death of the brain stem, and the diagnosis of brain death is now made by examining the function of nerves that originate in the brain stem ("brain stem criteria").⁷ Confirmatory tests such as electroencephalogram (EEG), cerebral angiography, and nucleotide radiography have been extensively investigated but are not generally required in adults, as each has significant limitations and none provide a "gold standard" with greater accuracy than clinical examination. The criteria of and tests required for the accurate diagnosis of brain death in children, particularly premature neonates, is more controversial and there may be a wider role for confirmatory testing in this setting.⁸ The terms "brain death"

and “brain stem death” are now frequently used interchangeably.⁹

THE “DEAD DONOR RULE”

The major impetus for medical, community, and legal acceptance of brain death is the need for organ donation from “beating heart” donors. A declaration of brain death is only used for this purpose, and is not a prerequisite for treatment withdrawal for other reasons. As Professor Lovell, a pioneer of renal transplantation in Australia, remarked: “The law did enter in a specific way . . . as the transplantation programme developed, because of the desire for a legal definition of death that was relevant to obtaining kidneys from cadavers”.¹⁰ In 1968 a Japanese surgeon conducted the first heart transplant operation in that country and was charged with unlawfully killing both the donor and the recipient. Since that time clinicians and policy makers have responded to the possibility of such events by insisting that donors of vital organs first be declared dead. This became known as the “dead donor rule”.

The dead donor rule solved the problem that organ donation appeared to involve a form of murder, and the redefinition of death as “brain death” allowed organ transplantation to continue.

DOES BRAIN DEATH PROVIDE A BIOLOGICALLY PLAUSIBLE DEFINITION OF DEATH?

It has been argued that death should be defined as the moment beyond which integration of the organism is lost. Some advocates of brain stem criteria for death argue that, for humans, the critical integrating system of that organism is represented by the brain stem, and that clinical death should therefore be equated with destruction of the brain stem.¹¹

When the concept of brain death was first introduced it was argued that death of the brain stem inevitably implied the imminent death of the whole body. In the past this was “proven” by showing that individuals who fulfilled the tests for the diagnosis of brain death inevitably had a cardiac arrest within weeks, even if provided with ventilation and intensive care.^{12–13} This appeared to provide good justification for defining death in terms of brain stem criteria. This argument is no longer tenable as medical therapy and intensive care have become increasingly sophisticated at replacing brain stem function,¹⁴ and we now know that bodies with a dead brain stem may be kept alive for prolonged periods of time.¹⁵ Brain dead pregnant women have been maintained for months and later given birth to healthy infants and brain dead children have been reported to survive for up to 14 years with ventilatory and nutritional support.^{16–17} In other words brain stem criteria can still be used to define prognosis, although the timing of death depends upon provision or withdrawal of intensive care.

Suggestions that the brain stem is the supreme regulator of the body seem both biologically and philosophically simplistic. Regulation of haematopoiesis, glucose metabolism, immunity, and many other bodily functions exist independently of the brain stem. Furthermore, the heart, the liver, the kidneys, and other organs are all required to maintain bodily integrity, and loss of the functions of any of these organs will result in eventual disintegration of the organism without artificial support. Many individuals who are clearly alive depend upon technology such as pacemakers, dialysis machines or even ventilators to live. Whether there is a “supreme regulator” therefore seems open to question. This argument may also be confused by the fact that the functions of the kidneys, heart, and lungs can be replaced by technological means, whereas that of the brain stem cannot. This is, however, very dependent upon technology; indeed aspects of brain stem function can now be replaced and it seems likely that more progress might be made in this area. Yet if there is a valid philosophical basis for any

definition of death, it should probably not be *entirely* dependent upon the state of present technology.

There is also some evidence that the brain continues to regulate some bodily functions in patients who meet the criteria for brain death.¹⁸ Between 22% and 100% of brain-dead patients in different studies have evidence of some control of water and electrolyte balance¹⁹ and many have other evidence of neurological regulation of hormonal secretion.²⁰ Nests of living cells may survive in the brains of some brain-dead people²¹ and at least one case has been recorded in which a patient had persistent cortical activity despite having absent brain stem function.²² Some EEG activity may be present in up to 40% of patients²³ and, while this may not represent “meaningful” function, in some cases such activity may be compatible with cortical function.²⁴ Patients who satisfy brain-death criteria may also respond to painful stimuli (such as surgical excision)—suggesting the existence of integrated neurological function at a brain level²⁵ and many may exhibit spontaneous or reflex movements.²⁶

In light of these findings, the argument that the brain stem is the sole or crucial regulator of bodily integration, and that this function is entirely eliminated in patients with brain death, does not withstand critical scrutiny.

IS THE BRAIN STEM IRREPARABLE OR BRAIN DEATH IRREVERSIBLE?

Developments in intensive care therapeutics are not the only thing to challenge the notion of the irreversibility of loss of brain function. Recent research into human embryonic stem (ES) cells has, for the first time, made neural tissue repair a possibility. Embryonic stem cells are clonal cell lines derived from the inner cell mass of the blastocyst or preimplantation embryo. They are pluripotent cells, that is, they are immature cells with the capacity to proliferate and differentiate into all cell lines, including myocardial and skeletal tissue, haematopoietic tissue, and neurons.²⁷ In vitro and animal studies have already demonstrated that ES cells may be differentiated into nerve cells,²⁸ including cells of the brain stem,²⁹ and that such cells may be biochemically and electrophysiologically active and may reverse cognitive and motor deficits.³⁰ Such ES cell “grafts” may therefore provide a theoretical basis for the treatment of neurodegenerative disease, stroke, and brain stem and spinal cord injuries.³¹ While ES cells have no current application, in the long term, as more is learned about neurological development, tissue repair and the replacement of brain function, the entire notion of irreversible loss of brain function will need to be revised. Indeed, advances in embryonic stem cell therapies that enable extensive tissue repair must inevitably lead to questioning of all notions of death that rely upon anatomical localisation, in much the same way that bypass surgery, heart transplantation, and artificial hearts has led to revision of cardiorespiratory criteria for death. What ES research has demonstrated is that the only tenable and technologically durable notion of death is that which is based upon permanent and irreversible loss of *function*, such as circulation or personhood.

COMMUNITY ATTITUDES TOWARDS BRAIN DEATH

Many commentators have noted that brain-dead people do not resemble our usual concepts of the dead. Brain-dead patients are pink and warm, their hearts beat and they continue to breathe with the aid of a ventilator. While attitudes about brain death may be changing in our community, a 1995 study showed that about 20% of families of brain-dead patients continued to have doubts about whether their relative was actually dead, even after brain death was explained to them, and a further 66% accepted that the patient was dead but felt emotionally that they were still alive. This experience did not appear to be related to whether families agreed or disagreed with organ donation.³²

Doctors and nurses also have difficulty in coming to terms with the concept of brain death. A study by Youngner *et al*³³ showed that many believe that brain-dead patients are “irreversibly dying” or have unacceptable quality of life rather than being actually dead. Nurses and physicians seem to talk to families as if patients were still alive, using statements such as: “If kept on the respirator, the patient will die of sepsis” or: “At this point in time it doesn’t look as if the patient is going to survive”.

Organ transplantation requires the use of living tissue for the purposes of transplantation. To those who believe that all human life is sacred, it is only possible to remove organs such as the heart and lungs from people who have already died. It has been suggested by critics of brain-death that the concept was introduced, not because its proponents really believed that such patients were dead, but as a “convenient fiction” that allowed the development of organ transplantation.³⁴

Yet if death is redefined in a way that is not in keeping with public perceptions, there is a risk that the public will become disillusioned about the process of organ transplantation. Within this context it is important to note that the two primary reasons the public gives for not signing donor cards are fear that doctors “might do something to me before I’m really dead” and fear that “doctors might hasten my death”.^{35 36}

It seems apparent that, although staff and patients see the need for the use of brain stem criteria for brain death for the development of transplantation, many act as if they do not really believe in the identification of brain death with “actual” death.

ALTERNATIVES TO BRAIN DEATH

Death of the “person”

Several alternative definitions of death have been proposed. Some argue in favour of defining death as the irreversible loss of that which is essentially significant to being an individual person.³⁷ Proponents of such definitions of death emphasise the importance of sentience, cognition, and “personhood” in defining life. “Personhood” has been variously described as rationality, sociality, self awareness, capacity for intentional behaviour, and the ability to conceive and carry out projects.³⁸

One major problem with such ideas is the absence of a clear definition, anatomic localisation, or tool to measure personhood.³⁹ This, in turn, makes it difficult to assess whether a patient is dead or not, and whether the state they are in is irreversible. Indeed some patients who are thought to have irreversible loss of consciousness do recover. In the end, the only robust means for establishing irreversible loss of personhood, appears to be the current brain stem criteria.

Some of the implications of “personhood” definitions of death seem unlikely to gain public support. For example, such definitions would allow patients thought to be permanently unconscious to be buried, cremated or have their vital organs removed.⁴⁰ according to Shann: “... [p]aradoxically, some of the strongest opposition to change, or even discussion of the issues involved, comes from the transplant lobby—who fear that any suggestion of change will be misinterpreted as an attempt to snatch organs, and so undermine public confidence in the system”.⁴¹

Circulatory death

Another approach to defining death would be a return to the old “cardiorespiratory” criteria that are based upon identification of irreversible cessation of circulation. (In most cases of organ donation it is necessary that the heart of the donor remain beating in order to maintain circulation to the organs.)

Recently, asystolic (non-heart beating) organ donation has re-emerged as an important strategy for securing viable kidneys for transplantation.⁴² This, in turn, has led to the adoption of several new guidelines that have implications for

definitions of death. For example, in the “Maastricht protocol”, the heart of a dying, critically ill patient is allowed to stop for ten minutes, then the kidneys are removed as rapidly as possible.⁴³ (Other authors have proposed waits of as little as two minutes before organ donation could commence.⁴⁴) The kidneys can be reliably restored to full function once out of the body (as can the heart).

Protocols such as these do not, however, demand the demonstration of irreversible cessation of circulation. They therefore seem to be inconsistent with the dead donor rule, unless the requirement for a fixed period of asystole is a new, unproven surrogate of brain death.

LEGAL ASPECTS OF BRAIN DEATH

Historically it has been left to the medical profession to certify death. When a medical practitioner is unable to certify death then the coroner needs to determine that death has occurred (for example, when there is no body available).

There are a number of reasons why the law requires death to be certified, some of which include:

- statistical/epidemiological purposes
- for the purposes of succession—the distribution of property
- to allow burial to take place
- for criminal law purposes where death is a criterion for the commission of a crime.

Until relatively recently, the criteria for death had been simple: death occurred when the heart stopped beating and the person stopped breathing.

Following the report of the Ad Hoc Committee of the Harvard Medical School⁵ a number of legislatures in North America and Australia were persuaded to enact legislation to provide a “legal” definition of death both to offer some degree of certainty and to satisfy some levels of public disquiet.⁴⁵ Other jurisdictions, England for example, chose not to pass legislation but relied upon courts to recognise brain function criteria in determining whether death has occurred.

LEGISLATIVE RESPONSES

The first North American jurisdiction to include brain death-criteria in a definition of death was Kansas in 1970.⁴⁶ Alternative criteria for death have been adopted in the United States *Uniform Determination of Death Act 1980*⁴⁷ and similar criteria were included in the draft legislation appended to the Australian Law Reform Commission (ALRC) report of 1977 entitled “Human Tissue Transplants”.⁴⁸ The Australian report advocated the recognition of two alternative criteria for death:

- irreversible cessation of all brain function, or
- irreversible cessation of blood circulation.

This definition of death has been adopted for all purposes of the law with respect to transplantation (except in Western Australia) and the general law (except in Queensland⁴⁹). Many other jurisdictions have legislated to define brain death, some using the short definition similar to that in the United States *Uniform Determination of Death Act 1980*⁴⁷ while others use very detailed criteria. For example, in the US State of Virginia the legislation requires 325 words to define when a person is medically and legally dead.⁵⁰

In some jurisdictions, however, the definition of death is not used for general purposes but is restricted to criteria to be used for cadaveric organ donation. For example, in Western Australia section 22 of the *Human Tissue and Transplant Act 1982* authorises the removal (under specified circumstances) of organs from a person who has died, but does not define death.⁵¹

NON-LEGISLATIVE RESPONSES

Not all countries have passed legislation defining death—for example, there is no legislated definition of death in England.

The English courts have developed the common law to recognise a brain stem criterion of death. In the case of *Re A* [1992] 3 Med LR 303 the court made a declaration that A, who had been certified as brain stem dead, was dead for all legal as well as all medical purposes—allowing ventilation to be lawfully discontinued.⁵²

The UK courts have emphasised that it is the death of the brain stem and not the loss of higher brain functions that is the minimum criterion for death.⁵³

LIMITS OF THE CURRENT DEFINITION OF BRAIN DEATH

When the ALRC recommended the adoption of the current criteria for defining death they were conscious of the need to recognise that medical knowledge would advance and they did not want to restrict the medical profession in its determination of death. Thus, the ALRC said in its report:

The brevity of the recommended statutory provision, and the deliberate omission of detailed criteria, may be taken as a reflection and confirmation of the Australian community's general confidence in the medical profession. The creation and prescription of techniques of diagnosis should be the responsibility of the medical profession. . . . The inclusion in the statutory provision of references both to "brain death" and to traditional criteria serves a useful purpose.⁵⁴

The draft legislation set out the limits for the medical determination of death while allowing flexibility in its application. The limits are that there must be *irreversible cessation of all brain function, or irreversible cessation of blood circulation*. The difficulty with these limits is that they are out of step with present practice. This legislation is based upon a "whole brain" definition of death, as it requires all brain function to be irreversibly lost. In medical practice, brain stem criteria, not whole brain criteria, are used to diagnose death. Yet, as discussed above, people may satisfy brain stem criteria yet continue to have evidence of some brain function. It appears therefore that the surrogate use of brain stem criteria for whole brain death may be legally questionable.

Proponents of brain stem criteria in Australia have argued that although the brains' of brain-dead people may continue to have some function, this function is of no real significance.⁵⁵ However, the question of the significance of brain function seems to be a separate point from the question of whether it is present or not.⁵⁶ The legal definition of death seems to be entirely based upon the latter question.

FUTURE DIRECTIONS

Definitions of death should allow a number of clinical questions to be addressed:

1. When can "life-support" be withdrawn from patients with irreversible neurological damage?
2. When can organs be removed from patients for transplantation?
3. When can a patient be cremated or buried?

It has been claimed that the concept of brain death provides a single, uniform answer to all three clinical questions. But in fact the answers to each of these questions appears quite distinct:

1. Life-support can be withdrawn from patients with irreversible neurological damage, irrespective of whether they are dead or alive, depending upon the wishes of the patient and an assessment of the burdens and benefits of treatment.

2. Organs are generally removed from patients who are brain-dead (heart-beating donors) but may also be removed from those who meet circulatory criteria (non-heart-beating donors).

3. People can only be buried or cremated when they satisfy circulatory criteria for death.

We believe that the term "death" should be reserved for people who meet circulatory criteria (identification of irreversible cessation of circulation of blood) while "brain death" should be regarded as a clinical diagnosis that can be used in exactly the same way as patients are advised that a gangrenous foot is dead, or that part of their heart muscle is dead (that is, as an attribute of the tissue involved rather than the organism as a whole). Brain stem criteria imply death of the brain stem, and are a surrogate marker for brain death. They are also of important prognostic significance—as they immediately imply that the patient has a permanent, irreversible loss of consciousness and that death is certain without continuation of ventilatory and intensive care support. Patients who meet these criteria may have treatment withdrawn on the basis that they have no hope of recovery, and they may also be considered to be potential donors for organ transplantation.^{57–59}

Organs can be taken from a human body at all stages of life, and at various stages in the dying process. Clinicians and policy makers have accepted the "dead donor rule" as the basis for organ donation, but this has required the use of artificial criteria (such as brain stem criteria) for defining the point of death. However, as can be seen these criteria are biologically implausible and inconsistent with any legislation. It is therefore necessary to change legislation (and public opinion) but maintain the "dead donor rule" or replace the "dead donor rule" with other processes for determining when organ donation can occur.

If the first approach is taken, the legislation could be amended to remove the notion of brain "function" as being one of the criteria for death. While the ALRC left identifying the criteria up to the Royal Australasian Medical Colleges, this may not be satisfactory as there should be an opportunity for some community input.

The alternative approach would be to abandon the "dead donor rule" and accept organ donation from patients without defining them as dead. The identification of brain stem death in this context would be of value for its prognostic value only. Such a conceptual shift would not change anyone's eligibility for organ donation. It would, however, place much greater emphasis on consent and on the complexities of the act of donation from patients and/or their families. If families are told that brain stem criteria define the point where consciousness is not recoverable and where physical recovery is impossible, but where organ donation is an option, although the patient is not yet dead, this may be more commensurable with common morality and may more honestly acknowledge the layers of moral difficulty than the present situation. Rather than redefining those who are "brain dead" as "dead" it may be more honest to acknowledge that such individuals are not dead and that removing their organs is in fact killing them. Such an action is undeniably morally troubling; it may, however, be morally justifiable in precisely defined circumstances such as where recovery is impossible and personal identity is lost. It may also be less morally objectionable than the creation of a fiction (the redefinition of death) which is the only alternative. The long term viability of transplantation programmes is likely to be better served by telling the truth than trading in fictions.

Any legislative response to this alternative would include adding an additional section to transplant legislation that would provide for the removal of organs from a person whose death is imminent (with clarification of what is meant by imminent). While this approach explicitly separates the definition of death from organ transplantation, it conflicts with

the dead donor rule and may be seen morally as causing death through organ removal. Given that death is not the primary intent, interesting questions about causation and the principle of double effect would arise. Any solution to these questions may require specific legislative provisions that would avoid the unintentional creation of criminal offences for acts that otherwise meet appropriate criteria.

CONCLUSION

If one examines the history of the the concept of brain death, it is clear that it is closely linked to developments in organ transplantation. By redefining death in terms of brain function, society's increasing need for organ transplants was put on a philosophical footing that would allow the expansion of transplant programmes. Unfortunately this led to great potential for a conflict of interests between the demand for organs, and the need for a scientifically and philosophically valid definition of human death.

While all scientific and medical endeavour takes place in a social and political context, death and dying retain a unique quality, being owned by all religions, communities and individuals. Seen in this light, any changes to practice and legislation in the declaration of death and donation of vital organs must be fully owned and supported by the broader community.

AUTHORS' NOTE

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REFERENCES

- 1 **Cranford R**. Even the dead are not terminally ill any more. *Neurology* 1998;**51**:1530-1.
- 2 **Truog RD**. Is it time to abandon brain death? *Hastings Center Report*. 1997;**27**:29-37.
- 3 **Van Norman GA**. A matter of life and death: what every anesthesiologist should know about the medical, legal and ethical aspects of declaring brain death. *Anesthesiology* 1999;**91**:275-87.
- 4 **Powner DJ**, Ackerman BM, Grenvik A. Medical diagnosis of death in adults: historical contributions to current controversies. *Lancet* 1996;**348**:1219-23.
- 5 **Ad Hoc Committee of the Harvard Medical School**. A definition of irreversible coma. *Journal of the American Medical Association* 1968;**205**:337-40.
- 6 President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research. Guidelines for the determination of death: report of the medical consultants on the diagnosis of death. *Journal of the American Medical Association* 1981;**246**:2184-6.
- 7 **Australian and New Zealand Intensive Care Society**. *Recommendations on brain death and organ donation* [2nd ed]. Melbourne: Australian and New Zealand Intensive Care Society, 1998.
- 8 **Okamoto K**, Suzumoto T. Return of spontaneous respiration in an infant who fulfilled current criteria to determine brain death. *Pediatrics*;1995;**96**:518-20.
- 9 **Lamb D**. *Death, brain death and ethics*. London: Croom Helm, 1988.
- 10 **Lovell RRH**. Ethics, law and resources at the growing edge of medicine. *Bioethics News* 1990;**10**:7-17.
- 11 **Pallis C**. Whole-brain death reconsidered—physiological facts and philosophy. *Journal of Medical Ethics* 1983;**9**:37.
- 12 **Pallis C**. *ABC of brain stem death*. London: BMJ, 1983: 123-4.
- 13 **Jennett B**, Hesse C. Brain death in Britain as reflected in renal donors. *British Medical Journal* 1981;**283**:359-62.

- 14 **Washida M**, Okamoto R, Manaka D, *et al*. Beneficial effect of 3,5,3-Triiodothyronine and Vasopressin administration on hepatic energy status and systemic haemodynamics after brain death. *Transplantation* 1992;**54**:44-9.
- 15 **Shann F**. A personal comment: whole brain death versus cortical death. *Anaesthesia and Intensive Care*, 1995;**23**:14-15.
- 16 **Field DR**, Gates EA, Creasy RK, *et al*. Maternal brain death during pregnancy: medical and legal issues. *Journal of the American Medical Association* 1988;**260**:816-22.
- 17 **Shewman DA**. Chronic brain death: meta-analysis and conceptual consequences. *Neurology*;1998;**51**:1538-45.
- 18 **Truog RD**. Organ transplantation without brain death. *Annals of the New York Academy of Science*. 2000;**913**:229-39.
- 19 **Schrader H**, Krogness K, Aakvaag A, *et al*. Changes of pituitary hormones in brain death. *Acta Neurochirurgia* 1980;**52**:239-48.
- 20 **Gramm HJ**, Meinhold H, Bickel, *et al*. Acute endocrine failure after brain death. *Transplantation* 1992;**54**:851-7.
- 21 **Veatch RM**. The impending collapse of the whole-brain definition of death. *Hastings Center Report* 1993;**23**:18-24.
- 22 **Jones JG**, Vucevic M. Not awake, not asleep, not dead? *Intensive Care Medicine* 1992;**18**:67-8.
- 23 **Truog RD**, Fackler JC. Rethinking death. *Critical Care Medicine* 1992;**20**:1705-13.
- 24 **Rodin E**, Tahir S, Austin D, *et al*. Brain stem death. *Clinical Electroencephalography* 1985;**16**:63-71.
- 25 **Hill DJ**, Munglani R, Sapsford D. Haemodynamic responses to surgery in brain-dead organ donors. *Anaesthesia* 1994;**49**:835-6.
- 26 **Sapesnik G**, Maurino J, Ryeri J. Movements in brain death. *European Journal of Neurology* 2001;**8**:209-13.
- 27 **Thomson JA**, Itskovitz-Eldor J, Shapiro SS, *et al*. Embryonic stem cell lines derived from human blastocysts. *Science* 1998;**282**:1145-7.
- 28 **Reubingoff BE**, Pera M, Fong C-Y, *et al*. Embryonic stem cell lines from human blastocysts: somatic differentiation in vitro. *Nature Biotechnology* 2000;**18**:399-404.
- 29 **Lee SH**, Lumelsky N, Studer L, *et al*. Efficient generation of midbrain and hindbrain neurons from mouse embryonic stem cells. *Nature Biotechnology* 2000;**18**:675-9.
- 30 **Bonn D**. First cell transplant aimed to reverse stroke damage. *Lancet* 1998;**352**:119.
- 31 **Gaerhart J**. New potential for embryonic stem cells. *Science* 1998;**282**:1061-2.
- 32 **Pearson IY**, Bazeley P, Spencer-Lane T, *et al*. A survey of families of brain dead patients: their experiences, attitudes to organ donation and transplantation. *Anaesthesia and Intensive Care* 1995;**23**:88-95.
- 33 **Youngner SJ**, Landefeld S, Coulton CJ, *et al*. Brain death and organ retrieval: a cross-sectional survey of knowledge and concepts among health professionals. *Journal of the American Medical Association* 1989;**261**:2205-10.
- 34 **Singer P**. *Rethinking life and death*. Melbourne: The Text Publishing Company, 1994.
- 35 **Annas GJ**. Brain death and organ donation: you can have one without the other. *Hastings Center Report* 1988;**18**:8-30.
- 36 **Wakeford RE**, Stepney R. Obstacles to organ donation. *British Journal of Surgery* 1989;**76**:435-9.
- 37 **Green M**, Wickler D. Brain death and personal identity. *Philosophy and Public Affairs* 1980;**9**:127.
- 38 **Lizza JP**. Persons and death: what's metaphysically wrong with current statutory definitions of death? *Journal of Medicine and Philosophy* 1993;**18**:351-74.
- 39 **Powner DJ**, Ackerman BM, Grenvik A. Medical diagnosis of death in adults: historical contributions to current controversies. *Lancet* 1996;**348**:1219-23.
- 40 **Angell M**. After Quinlan: the dilemma of the persistent vegetative state. *New England Journal of Medicine* 1994;**330**:1524-5.
- 41 **Shann F**. A personal comment: whole brain death versus cortical death. *Anaesthesia and Intensive Care* 1995;**23**:14-15.
- 42 **Kootstra G**. The asystolic, or non-heartbeating, donor. *Transplantation* 1997;**63**:917-21.
- 43 **Booster MH**, Wijnen RMH, Ming Y, *et al*. In-situ perfusion of kidneys from non-heart-beating donors: The Maastricht protocol. *Transplant Proceedings* 1993;**25**:1503-4.
- 44 **University of Pittsburgh Medical Center**. Policy and procedure manual: management of terminally ill patients who may become donors after death. In: Arnold RM, Youngner SJ, Shapiro R, *et al*, eds. *Procuring organs for transplant. The debate over non-heart-beating cadaver protocols*. Baltimore: Johns Hopkins University Press, 1995:235-49.
- 45 **Kennedy I**, Grubb A, eds. *Principles of medical law* Oxford: Oxford University Press, 1998.
- 46 **See reference 45: ch 77-202: Kan Stat Ann**.
- 47 **Uniform Determination of Death Act 1980, USA**.
- 48 **Australian Law Reform Commission**. *Human tissue transplants*. Canberra: Australian Government Printing Service, 1977.
- 49 **Transplantation and Anatomy Act 1979: s 45**.
- 50 **Virginia General Assembly; 54.1-2972**.
- 51 **Human Tissue and Transplantation Act 1982: s 22 in Western Australia**.
- 52 **Re A [1992] 3 Med LR 303**.
- 53 **Airedale NHS Trust v Bland [1993] AC 789**.
- 54 **See reference 48: para 137**.
- 55 **Transplantation Ethics Working Party**. *Certifying death: the brain function criterion; ethical issues in organ donation: discussion paper no 4*. Canberra: National Health and Medical Research Council, 1997.

- 56 **Bernat JL**. How much of the brain must die in brain death. *Journal of Clinical Ethics* 1992;**3**:21–6.
- 57 **Australian and New Zealand Intensive Care Society**. *Statement and guidelines on brain death and organ donation*. Carlton, Victoria, Australia: Australian and New Zealand Intensive Care Society, May 1993.
- 58 **Australasian Transplant Coordinators Association Inc**. *National guidelines for organ and tissue donation*. Sydney, NSW, Australia: Australasian Transplant Coordinators Association Inc, 1993.
- 59 **Kennedy MC**, Moran JL, Fearnside M, et al. Drugs and brain death. *Medical Journal of Australia* 1996;**165**:394–7.