OBJECTIVE: Specific guidelines for documenting the complete loss of brain function, for the declaration of brain death, have been established for 3 decades. This study assessed the quality and completeness of brain death notes and the effects of delays between notes on organ procurement.

METHODS: A retrospective review of brain death declarations at a major medical center was performed. Fifty-eight cases, with a total of 121 brain death notes, were identified in a 12-month period. Notes were assessed for clinical and confirmatory tests of brain and brainstem function. Adverse physiological events that occurred in the time intervals between notes were also identified.

RESULTS: The clinical tests most likely to be documented were tests of pupillary (86%) and gag (78%) reflexes. Corneal reflexes were tested in only 57% of cases, and motor responses were noted in only 66%. Documentation by the neurosurgery department was generally more complete. The delays between brain death declarations were highly variable but did not result in any loss of donor organs because of hemodynamic derangements.

CONCLUSION: To meet the needs of organ recipients and donor families and to comply with hospital, legal, and legislative mandates, hospitals may need to increase quality assurance activities with respect to declarations of brain death. Increased physician education should improve awareness of uniform brain death declaration guidelines.

KEY WORDS: Apnea testing, Brain death, Documentation, Quality assurance

In 1968, an ad hoc committee of the Harvard Medical School proposed that the absence of brain function be defined as death (1). That publication clarified and standardized the criteria for determining “brain death” at a time when only 9% of the public thought of death in terms of loss of brain function. Since then, there has been a profound change in the way Americans view the passing of life (3).

In 1971, the Conference of Medical Royal Colleges further defined brain death as complete irreversible loss of brainstem function, validating clinical tests of brainstem function as essential for the diagnosis of brain death (9, 14). This difference between the American and British systems persists today, with the former using whole-brain criteria and the latter using brainstem criteria.

The President’s Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research refined brain death standards by incorporating complicating conditions that could interfere with clinical examinations, such as hypotension, hypothermia, and intoxication (18). On the basis of these experiences, the American Academy of Neurology published practice guidelines with specific practical algorithms for diagnosing brain death (19). Brain death has
since become a well-recognized, albeit often poorly understood, concept. Although clearly defined from a scientific standpoint, brain death remains at the crossroads of medical ethics, law, and cross-cultural medicine.

In the United States, the legal basis for the determination of death according to neurological criteria involves the Uniform Determination of Death Act. This document, which was drafted in 1980 by the National Conference of Commissioners of Uniform State Laws, focuses on the concept of the irreversibility of cessation of brain function (22). Laws providing for brain death currently exist in all 50 states in the United States.

Although the legal community defines brain death as “irreversible cessation of all functions of the entire brain,” no specific standards for the actual determination of this state are provided (4, 22). In a prefatory note, the Commissioners state the following.

This act is silent on acceptable diagnostic tests and medical procedures. It sets the general legal standard for determining death, but not the medical criteria for doing so. The medical profession remains free to formulate acceptable medical practices and to utilize new biomedical knowledge, diagnostic tests, and equipment (22).

Therefore, specific standards of medical practice for brain death determination remain merely guidelines, and brain death declarations are made according to criteria determined by individual hospitals.

Neurosurgeons, with neurologists and intensivists, frequently care for patients devastated by neurological accidents, and the neurological community has historically been involved in brain death policy formulation, dating back to the involvement of William Sweet with the Harvard Committee (17). Neurosurgeons and neurologists have particular expertise in assessing brain function and can educate other health care professionals with respect to the physiological processes, criteria, and legal issues associated with brain death (12).

The determination of death according to neurological criteria remains one of the most serious roles of physicians. Nevertheless, there have been no published studies of the quality of brain death assessments by physicians in the United States. This article examines compliance with accepted guidelines for the determination of brain death at a single institution.

PATIENTS AND METHODS

Seventy-eight patients were declared brain dead at the Los Angeles County General Hospital between January 1 and December 31, 1999. This hospital serves as the major regional trauma center for Los Angeles County, treating more than 25% of all trauma cases in the county. Eighteen hundred patients underwent organ harvesting (Table 2).

Complete charts were available for 58 of those patients, and a retrospective analysis of those cases was performed. Patient demographic data and brain death notes were analyzed, and data on tests and examinations performed before referral to organ procurement services (which often ordered more tests and examinations) were collected.

In each case, the number of brain death notes and the time interval between notes were determined. Components of each note were then categorized as 1) single-step neurological examinations (papillary reaction, corneal reflex, gag reflex, oculocephalic reflex, or motor response assessments), 2) multistep neurological examinations (cold caloric testing or apnea testing), and 3) confounding factors (temperature, toxicology screening results, oxygen saturation, and blood pressure). The use of confirmatory tests (EEG and radionuclide studies) was also determined.

Adverse physiological events that occurred after the time of the first note and before the declaration of brain death were identified. These events were defined as systolic blood pressure of less than 60 mm Hg despite pressor treatment, oxygen saturation of less than 90% despite maximal ventilator oxygenation, urine output of less than 30 ml/h for ≥2 hours, or malignant cardiac arrhythmias.

RESULTS

A total of 58 patients were included in this study. The causes of brain death are presented in Table 1, and the age distribution is presented in Figure 1. Seventy-one percent of the patients were male. Twenty-seven patients ultimately underwent organ harvesting (Table 2).

A total of 121 brain death notes were written. Notes were written by neurosurgery (57 cases), trauma surgery (25 cases), general surgery (8 cases), neurology (7 cases), medicine (10 cases), and other (14 cases) services. The time intervals between notes are presented in Table 3. In no case was a second note written by the neurosurgery service less than 6 hours after the first note.

Brain Death Documentation

Table 4 presents the percentages of brain death notes documenting each of 11 components of a complete brain death examination. Single-step neurological examinations were doc-

<table>
<thead>
<tr>
<th>TABLE 1. Causes of death</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blunt head trauma</td>
<td>17</td>
</tr>
<tr>
<td>Subarachnoid/intracerebral hemorrhage</td>
<td>15</td>
</tr>
<tr>
<td>Gunshot wound to head</td>
<td>14</td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>Anoxia</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
</tr>
</tbody>
</table>
umented with the greatest frequency (57–86%), whereas multistep neurological examinations and confounding factors were documented with less frequency (28–76%). Three patients underwent radionuclide flow studies. No patients underwent EEG, angiographic, or transcranial Doppler ultrasonographic studies for confirmation.

Neurosurgery notes contained a median of 9 of 11 possible components (mean, 8.3 components), compared with non-neurosurgery notes, which contained a median of 6 components (mean, 5.9 components) (Fig. 2). Neurosurgery notes were, however, less likely to document oxygen saturation, toxicology screening, and caloric testing results.

**Adverse Events**

In the time interval between the first and last brain death notes, five patients experienced brief episodes of hypotension (defined as mean arterial blood pressure of <60 mm Hg). Three patients experienced episodes of desaturation (defined as oxygen saturation of <90%, apart from apnea testing). No patients exhibited decreased urine output (<30 ml/h) for more than 1 hour. None of these transient events was considered to have affected the viability of the donor organs.

Three patients died in the interval between the first and second brain death notes. However, all of those patients exhibited severe physiological derangements even before the first notes. Those patients were unlikely to have become vital organ donors on the basis of their initial presentations. Therefore, no organs were lost because of physiological derangements or end organ perfusion abnormalities that occurred during the observation period between notes.

**DISCUSSION**

**Brain Death Examinations**

The concept that cessation of brain function indicates the death of the human organism was first recorded in the 12th century by Moses Maimonides, in observations of decapitated human subjects (6). Since then, modern concepts of brain death have become widely accepted in westernized nations.

Currently, most states in the United States require no special qualifications or training, beyond a general medical license, for individuals performing brain death examinations. California law requires only that two licensed physicians make the diagnosis on the basis of a clinical examination and confirmatory test results. California law requires only that two licensed physicians make the diagnosis on the basis of a clinical examination and confirmatory test results. The Virginia brain death statute is unique, in that it requires a “specialist in the field of neurology, neurosurgery, or electroencephalography” to assist in making the determination (Va Stat Sec 54-1-2972) (5).

The competence of physicians performing brain death examinations has not been well studied (24), but some variability in the quality of these examinations would be expected. In a survey of 112 neurologists and neurosurgeons by Black and Zervas (8), wide variations in the clinical criteria used to determine brain death were noted. Our study, although limited to a single institution, demonstrates poor compliance with accepted brain death guidelines. Our results are similar to those of the multicenter English study by Keogh and Akhtar (13), which noted complete documentation of brainstem function for only 44% of patients referred for organ procurement.

In our study, examinations completed by the neurosurgery service were more complete, with an average of 2.4 more criteria in each note. Nevertheless, 28% of neurosurgery notes failed to include corneal reflex test results. Certain tests required documentation only once per patient. Therefore, although only 28% of notes documented negative toxicology screening results, 48% of patients demonstrated negative screening results. Similarly, caloric testing would not be required for patients without an ocu-
locephalic reflex, and oculocephalic reflexes would not be assessed for patients with suspected spinal injuries.

Incomplete assessments of brain function undoubtedly occur in cases in which there is no uncertainty regarding brain death. However, the specific neurological tests recommended by the various brain death commissions are intended to exclude other causes of impaired consciousness. In the United States, whole-brain criteria (the irreversible cessation of all brain function) are used to diagnose brain death. An alternative “neocortical” approach defines brain death as the loss of only higher brain function. Physicians who use a higher function definition of brain death presumably also could favor the withdrawal of life-sustaining interventions in cases of anencephaly and the persistent vegetative state. Although no governments use a “neocortical” definition of brain death, one-third of the physician respondents in a survey study by Younger et al. (25, see also 16) applied the neocortical definition of brain death, as evidenced by their support for organ procurement from patients in a vegetative state.

**Observation Periods**

Delays between serial brain death examinations were originally proposed to reduce the likelihood of erroneous diagnoses of death. The President’s Commission guidelines (18) speak of “an appropriate period of observation and/or trial of therapy” but do not indicate what that time period should be; the recommendations by the American Academy of Neurology specify only that the delay be no more than 24 hours (19).

In the study by Flowers and Patel (10), serial notes separated by a time interval were supported by confirmatory radionuclide or EEG studies. Of 203 cases of adults who were clinically observed to be brain dead, all except six cases were confirmed with EEG studies or radionuclide scanning. Five of the six questionable cases were noted to have absent blood flow in follow-up studies, and one patient died as a result of cardiac arrest in the interim (10). Therefore, no erroneous declarations of death occurred with properly performed clinical examinations separated by a time interval.

In this study, there was wide variation in the observation times between notes, and none of the patients who were in hemodynamically stable condition at the time of the first brain death note subsequently exhibited instability. Organ procurement specialists advocate shortening or eliminating these delays to reduce the incidences of ischemia and neurohumorally mediated damage to vital organs (23), but we were unable to identify cases in which vital organs became nonviable because of these delays.

For adults, we typically wait 6 hours between brain death examinations to confirm the diagnosis, but exceptions to this practice clearly exist. In some cases, the pathological mechanisms of injury or preceding clinical events make the diagnosis of brain death clear. We rely almost completely on clinical examinations and do not order confirmatory testing (EEG, angiographic, and

---

**TABLE 4. Examination components performed**

<table>
<thead>
<tr>
<th>Documentation (% of notes)</th>
<th>Neurosurgery</th>
<th>Neurology</th>
<th>Trauma</th>
<th>Medicine</th>
<th>Surgery</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of notes</td>
<td>57</td>
<td>7</td>
<td>25</td>
<td>10</td>
<td>8</td>
<td>14</td>
<td>121</td>
</tr>
<tr>
<td>Single-step neurological tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pupillary reflex</td>
<td>89</td>
<td>57</td>
<td>84</td>
<td>90</td>
<td>100</td>
<td>86</td>
<td>86</td>
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<tr>
<td>Corneal reflex</td>
<td>72</td>
<td>71</td>
<td>36</td>
<td>40</td>
<td>63</td>
<td>36</td>
<td>57</td>
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<tr>
<td>Gag reflex</td>
<td>96</td>
<td>71</td>
<td>68</td>
<td>60</td>
<td>13</td>
<td>71</td>
<td>78</td>
</tr>
<tr>
<td>Oculocephalic reflex</td>
<td>74</td>
<td>57</td>
<td>64</td>
<td>40</td>
<td>63</td>
<td>36</td>
<td>63</td>
</tr>
<tr>
<td>Motor response</td>
<td>86</td>
<td>86</td>
<td>56</td>
<td>50</td>
<td>25</td>
<td>29</td>
<td>66</td>
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<tr>
<td>Multistep neurological tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caloric testing</td>
<td>11</td>
<td>43</td>
<td>40</td>
<td>30</td>
<td>63</td>
<td>50</td>
<td>28</td>
</tr>
<tr>
<td>Apnea testing</td>
<td>84</td>
<td>43</td>
<td>84</td>
<td>40</td>
<td>88</td>
<td>64</td>
<td>76</td>
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<td>Confounding factors</td>
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<td></td>
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<td></td>
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<tr>
<td>Temperature</td>
<td>82</td>
<td>0</td>
<td>68</td>
<td>40</td>
<td>88</td>
<td>50</td>
<td>68</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>89</td>
<td>0</td>
<td>36</td>
<td>60</td>
<td>75</td>
<td>21</td>
<td>62</td>
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<tr>
<td>Oxygen saturation</td>
<td>25</td>
<td>14</td>
<td>28</td>
<td>40</td>
<td>50</td>
<td>29</td>
<td>42</td>
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<tr>
<td>Toxicology screening results</td>
<td>26</td>
<td>0</td>
<td>48</td>
<td>20</td>
<td>63</td>
<td>14</td>
<td>28</td>
</tr>
</tbody>
</table>

**FIGURE 2. Number of brain death parameters used in determining brain death.**
radionuclide studies) for adults, except under special circumstances in which the family has requested the tests to accelerate the organ procurement process or in the presence of long-acting barbiturates. Computed tomographic angiography is an emerging technology that may be helpful in this area in the future. For children under the age of 5 years, a 12-hour delay is recommended, because of a presumed but unproved resilience of the developing nervous system; confirmatory testing also might be used more for this patient population (2).

**Recommendations**

On the basis of the findings of this study and previous studies, we have begun to institute changes in the brain death declaration process at our institution. 1) We are implementing a standardized checklist in cases of brain death. This is intended to result in more thorough examinations, particularly when used by physicians who do not frequently participate in this process. 2) Neuroscientist (neurologist, neurosurgeon, intensivist, or neuroanesthesiologist) participation will be required in all cases, because omissions by nonspecialist physician examiners might reflect unfamiliarity with brain death examination criteria or lack of experience in performing the more complex multistep examinations. Although implementation of this recommendation might not be realistic in small hospitals, it is a reasonable expectation for large tertiary centers such as ours. 3) Education regarding the accepted standards for brain death declaration is now being provided for physicians and nurses involved in the care of these patients. At our institution, the medical staff office will also be certifying physicians who have completed a course on brain death standards. This process is intended not only to reduce errors in the diagnosis of brain death but also to increase the rates of donor gifting (20). 4) Because we have been unable to demonstrate a loss of donor organs during the time interval between notes, we continue to wait 6 hours between examinations. Nevertheless, we recognize the controversy surrounding this issue and continue to prospectively monitor for any adverse events that might result in the loss of life-saving organs.

Physicians are trusted to rigorously apply accepted standards and practices when making the diagnosis of brain death. Failure to strictly adhere to the whole-brain guidelines jeopardizes the public’s trust in the clinical diagnosis of brain death.

**REFERENCES**


**COMMENTS**

The definition of brain death might best be considered an operational definition, in which certain steps define the condition. It is therefore critically important to perform the steps carefully.

In this article, Wang et al. describe a model quality-improvement initiative in brain death diagnosis at Los Angeles County General Hospital. They analyzed the process, iden-
tified several apparent deficiencies, and prescribed changes to improve the process. It is difficult to determine the extent to which these findings can be generalized. Chart review is a notoriously poor method of obtaining reliable information; for example, there may be major differences between what was actually performed and what was documented. Furthermore, with only 58 of the 78 charts being reviewed, the account provided here might not accurately represent even the practice at the Los Angeles County General Hospital.

The points made in the article are valid, however. Every institution should have a policy for brain death declaration; a checklist is one way of ensuring that the conditions are met. Other suggestions include required involvement of a neurosurgeon, neurologist, or neuroanesthesiologist in diagnoses, a mechanism for review of compliance, and a course of education for the staff. These suggestions would be worth following and would help protect the diagnosis of brain death in both concept and application.

Peter McL. Black
Boston, Massachusetts

The authors have reviewed the history and practice of brain death documentation. This has been an extremely important topic in the past 30 years, during which we have progressed from controversy regarding the very validity of the concept of brain death to well-defined guidelines that we all can follow. The authors have emphasized how important it is to document the requirements for a diagnosis of brain death. Failures in this documentation have important legal ramifications and can expose physicians to criminal charges. Criminal charges have occasionally been pursued, albeit unsuccessfully in all cases (to my knowledge). The guidelines described conform to current legal requirements and should serve to settle the controversies regarding brain death that still occasionally arise. It is extremely important that those who will use the organs are not alone in determining brain death. This means that neurosurgeons play important roles at most institutions. I think we all should press our own hospitals to adopt similar documentation guidelines.

Donlin M. Long
Baltimore, Maryland

Wang et al. present a retrospective review of the documentation of brain death. Somewhat disappointingly, they observed that the criteria that are generally used throughout the United States were not uniformly applied and that there was failed documentation of the corneal reflex in 43% of cases and of the motor examination in 34% of cases. This is clearly inadequate and represents a failure to objectively perform a procedure that has profound implications for both the families of the patients and the potential recipients of donated organs. Quality assurance activities in this area must be improved, and the authors have provided a series of recommendations that I think are very useful. The issue is an important one; as the authors point out, we have been granted a trust, which we must rigorously preserve when making a diagnosis of brain death.

Lawrence F. Marshall
San Diego, California

Future Meetings—Congress of Neurological Surgeons

The following are the planned sites and dates for future annual meetings of the Congress of Neurological Surgeons:

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Philadelphia, PA</td>
<td>September 21–26</td>
</tr>
<tr>
<td>2003</td>
<td>Denver, CO</td>
<td>October 18–23</td>
</tr>
<tr>
<td>2004</td>
<td>San Francisco, CA</td>
<td>October 16–21</td>
</tr>
<tr>
<td>2005</td>
<td>Boston, MA</td>
<td>October 8–13</td>
</tr>
<tr>
<td>2006</td>
<td>Chicago, IL</td>
<td>October 7–12</td>
</tr>
</tbody>
</table>

Future Meetings—American Association of Neurological Surgeons

The following are the planned sites and dates for future annual meetings of the American Association of Neurological Surgeons:

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>San Diego, CA</td>
<td>April 26–May 1</td>
</tr>
<tr>
<td>2004</td>
<td>Orlando, FL</td>
<td>May 1–6</td>
</tr>
<tr>
<td>2005</td>
<td>New Orleans, LA</td>
<td>April 16–21</td>
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<tr>
<td>2006</td>
<td>San Francisco, CA</td>
<td>April 22–27</td>
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