Arguments Supporting the Brainstem Criterion

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In the debate about whether the whole-brain criterion or the brainstem criterion represents the best formulation of death by neurologic criteria—sometimes called the transatlantic divide due to the opposing conceptual positions in the United States and the United Kingdom—one figure looms large: Professor Christopher Pallis (Fig. 1) [1]. Pallis was a fierce defender of the concept of death by neurologic criteria, but he was also the strongest advocate for the brainstem formulation. Today he would be called an influencer.

Professor Pallis was the Reader Emeritus in Neurology at the Royal Postgraduate Medical School, London and at the Hammersmith Hospital until he retired in 1982. He died in 2005. Pallis came to great prominence in the debate about death by neurologic criteria following a TV show produced by the BBC documentary program Panorama entitled "Transplants—are the donors really dead" [2]. Against strong medical opposition, Panorama proceeded with transmission of this program in the United Kingdom on October 13, 1980 [3]. The program made claims that patients recovered after determinations of death by neurologic criteria and that doctors in the United Kingdom were carrying out determinations of death by neurologic criteria incorrectly and unsafely.

This program provoked a huge outcry by the medical profession and a press conference was organized on Tuesday, November 25, 1980 where Professor Pallis, and others, presented [3]. Pallis reminded the audience that none of the patients shown on the show would have been declared dead by neurologic criteria in any jurisdiction. Nine publications would follow in the *British Medical Journal* over the winter of 1982–1983 in which Pallis defended death by neurologic criteria, the

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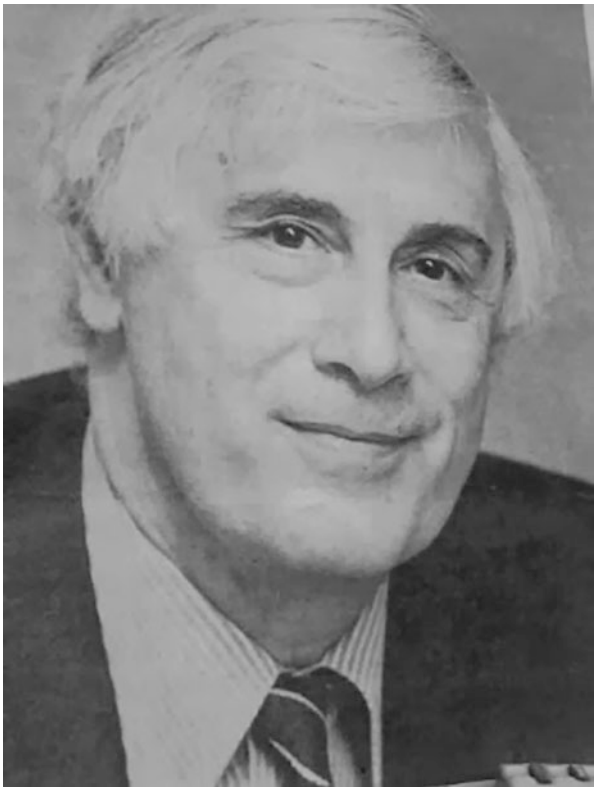

Fig. 1 Christopher Pallis. Image kindly provided to one of the authors (DG) by Professor Pallis's family

brainstem criterion, and the United Kingdom's approach [4–12]. These papers would be assembled in 1983 as a simple yet era-defining book *The ABC of Brainstem Death* that went through two editions and remained a key resource in many intensive care units until very recently [13, 14].

In this chapter, we outline the legacy of Pallis and his ongoing influence on our understanding of death by neurologic criteria and on the coherence that can be achieved between the concept of death and the standards used to determine it if one accepts the brainstem criterion. We remind readers that the clinical tests for determination of death by neurologic criteria largely examine the brainstem, so that it is the anatomy of the brainstem that unites death by neurologic criteria globally. We argue, like Pallis, that there is a hierarchy of functions that should count when determining human death, and we will show the incoherence of definitions and criteria that insist on the loss of ALL functions of the entire brain, which can only lead to dispute and challenge. We support the standard neurologic teaching that there is no possibility of the cortex being conscious without the brainstem. This is why the entire brain standard is unnecessary. If one accepts the brainstem criterion, then one is better poised to anatomically align definition and criteria to function. A comparison of recent legal cases in the United Kingdom, Canada, and the United States highlights the difficulties that occur if incoherent medical concepts, laws, and

practice are allowed to persist. Finally, this chapter answers some criticisms levelled against the brainstem criterion and reflects on the growing evidence base on the importance of the brainstem as the anatomical seat of rudimentary consciousness and the building block for all human consciousness.

1 The Legacy of Christopher Pallis

Apart from the obvious lesson that poorly researched journalism with a sensational and macabre bent will cause societal damage (a lesson seldom heeded in the decades that have followed), Pallis bequeathed to us, the next generation of critical thinkers on the topic of the determination of death, a number of conceptual legacies. First, he taught us that determining death should be a clinical diagnosis. A determination of death is like any other medical diagnosis and is satisfied when certain specified criteria are met. According to Pallis, the best defense against diagnostic errors when applying criteria requires the use of the clinician's brain, not technology – not even some machine. When clinicians are careful and well-trained, the risk of misdiagnosis can be avoided. Second, he taught us that not only is death the loss of biological function but that some functions count more than others. Death is the loss of the capacity for consciousness and breathing, both anatomically located in, and reliant on, a functional brainstem. The loss of brainstem function should, he claimed, be the determinant of human death.

1.1 The Determination of Death is a Clinical Diagnosis

The claim that "death is a clinical diagnosis" reminds us that medicine is concerned with biological processes. Death has not always been a clinical diagnosis determined by doctors. The Hippocratic tradition has been that, as death approached, or seemed to approach, doctors withdrew from patient care and gave way to the family and priests [15].

We would not do justice to Pallis in our analysis if we did not acknowledge his wickedly biting humor [16]. His work is, unexpectedly for scientific papers, often peppered with limericks, some of his own creation, others anonymous.

As Pallis wrote in 1982,

> In the heat of the public controversy about brain death two years ago a limerick was written which summed up the simple wisdom that death is a process:
>
> In our graveyards with winter winds blowing
> There's a great deal of to-ing and fro-ing
> But can it be said
> That the buried are dead
> When their nails and their hair are still growing? [4, p. 1411]

Of course, Pallis would be the first to acknowledge that the apparent growth of hair and nails after death is an artifactual illusion. What Pallis is directly expressing by

quoting the limerick is the long-held human fear of being buried alive [17, 18], which in more modern settings is often manifested, like in the Panorama program, in the fear that organ donors are not really dead.

If Pallis is the champion of medical reassurance of the twentieth century, Eugène Bouchut was the champion of the nineteenth century. The Academy of Sciences in Paris had observed that for 50 years in Germany, in an effort to prevent premature burial, the apparently dead had to be placed in stone and unrefrigerated buildings for a number of days (often three) before burial was allowed [19]. Not surprisingly, nobody recovered to life, but families still had to pay for the body to be observed. The Academy of Sciences resolved to offer a cash prize to the physician who successfully made "the diagnosis of death safe, prompt and easy" [19]. The prize was won by Bouchut in 1846 for his Trâité des Signes de la Mort (Treatise on the signs of death) [19]. He made two compelling arguments that were accepted by the Academy. The first was that it should be doctors who determine death and they should be paid for doing so. This would aid public safety in preventing premature burial. His second argument addressed the need for ease and timeliness. A doctor should determine death using four diagnostic criteria. Fascinatingly, three of these are neurologic criteria and only one is cardiovascular:

1. Absent breath.
2. Loss of feeling and movement.
3. Dilation of the pupil.
4. Absent heart sounds by use of a stethoscope for 5 minutes.

1.2 Clinical Diagnoses Have Criteria

Why choose doctors for the societal task of determining death? Doctors, as practitioners of medicine, use and employ the diagnostic process. Diagnoses follow rules which gives them safety and timeliness, while also implicitly allowing for medical advances over time to provide new diagnostic criteria for even greater certainty. This, so society judged, is the best way to determine death. Integral to criteria and associated with any diagnostic process, but perhaps less appreciated by society, are concepts of sensitivity and specificity. In any diagnosis, there must be the possibility of true positives, false positives, true negatives, and false negatives. This is a conceptual truth about the diagnostic process. It accepts the possibility of error, even as it strives for accuracy and improvement over time. The process whereby a rheumatologist diagnoses rheumatoid arthritis follows a similar process to an intensive care doctor making a determination of death by neurologic criteria: a diagnosis is made if the relevant set of criteria are met. We must understand what doctors are doing when they determine death. Doctors are not making a spiritual or familial pronouncement; they are doing what they always do, using criteria to make a diagnosis. Pallis's legacy, that death first and foremost should remain a clinical diagnosis with clear and established criteria, continues to be supported in medical consensus and courts [20, 21].

What may not have sufficiently emerged yet in this chapter is the *pragmatism* inherent to medicine and to the diagnostic process. The Academy of Sciences in Paris recognized a challenge that persists to this day, namely to identify a moment within a continuous biological process of failure and decay that can be determined by doctors and the wider health community as the moment of death, while also being acceptable to lawmakers and society. The moment in question, as the Academy sought, has to be capable of being safely, promptly, and easily identified [19]. These requirements can pull in different directions [22].

The requirement of safety means there can be no coming back to life after death is declared. "Easily" does not mean slipshod in medicine: it means reproducible, clear, and acceptable. Easily identifiable criteria promote safety by increasing accuracy and decreasing interobserver variability. This can still require, as both Bouchut and Pallis advocated, the experience of well-trained doctors. While Bouchut was quick to employ the latest technological aid to assist doctors in determining death, Pallis was more cautious regarding technology. He argued that the determination can and should be a bedside clinical diagnosis and that the best defense against errors was "common sense by experienced and humane physicians [8]." He was therefore against the use of the electroencephalogram (EEG) as a diagnostic aid in determining death by neurologic criteria. Stirring up the transatlantic divide, Pallis stated: "Many American jurors have a touchingly naive faith in the supremacy of machines [12]." The failings of EEG have only become more obvious over time, and it is now difficult to justify their use as an ancillary test [21, 23, 24]. Promptness, or timeliness, is important because the determination of death is not just a medical determination; it has societal, legal, and familial ramifications. The declaration of death by a doctor allows bereavement to formally start, grants family permission to leave the bedside, allows autopsies to commence (very rapidly in warm autopsies), organs to be recovered, and the body to be buried. We may also need an easy way to determine who might inherit under a will using the rules of probate: if both members of a couple die in an accident, we sometimes need to know who died first [25].

Recognizing the tension between safety, ease, and timeliness led the Academy of Sciences to seek a workable medical answer. Rigor mortis as a criterion of death may be safe, but it is not very timely, and according to those concerned about premature burial, not even easy to recognize [26]. The accepted criteria used by doctors to determine death are therefore critical for navigating this tension. What is required are clear diagnostic criteria, which doctors can be trained to recognize so that when a declaration of death is made, the receivers of this pronouncement are accepting.

1.3 Death Is the Loss of Biological Function in the Brain

The clinical criteria, which doctors use to determine death, rely on the identification of loss of biological function in a human being. The alternative perspective might be that a non-biological process determines when human death occurs. An example would be when the soul leaves the body. However, there are no workable criteria for determining when death has occurred in this sense. As we have seen, there has been

a societal shift away from priests determining death to doctors. This historical observation should act as a warning to doctors that trust once given can be taken away. A heavy responsibility and duty remain on medicine and science to provide coherent explanations of human death and for death to be determined in a safe and timely manner.

The birth of intensive care in the 1950s only made the job harder [22]. Unlike throughout all of human history, developments in technology meant that brain arrest and circulatory arrest no longer had to coincide. It was now possible for mechanically ventilated patients to permanently lose brain circulation and function, including the ability to breathe spontaneously, yet their hearts continue to beat and other organ and cellular functions to persist. This raised an important conceptual question: did all functions of the body need to cease for death to occur, or only some? This question cannot be answered solely empirically. Human decision sometimes has a role to play in answering such conceptual questions. Empirically, we discovered that brain arrest and circulatory arrest no longer had to coincide. However, that is not the same as *discovering* that patients who had suffered brain arrest were *dead*. A societal decision had to be made to decide whether loss of brain function counted as death. Society decided that people who had suffered "a permanently nonfunctioning brain" were dead [27].

Pallis, and many others then and since, would often use the example of decapitation to defend the societal decision [14, 28]. This was on the basis that most people accept that death has occurred at the moment of decapitation, even if, as would usually occur, the heart continues to beat for a period. Death by neurologic criteria is, by analogy and by loss of function, *physiological* decapitation. This claim has not been without conceptual and physiological challenge and response [29, 30]. Yet recognition of the preeminence of brain function over other bodily functions has only increased as medicine advanced to be able to replace all other organ functions except the brain, e.g., through dialysis, cardiopulmonary bypass for cardiac surgery and extracorporeal membrane oxygenation (ECMO) technology, and transplantation of organs [25]. The decisive point is that, if we replaced your brain with another brain donated by a third party, it would no longer be you who woke up following the operation. This is not true of any other transplanted organ. Although attempts have been made to respond to this point [31], they all fail [22, 28].

1.4 Some Functions in the Brain Count More Than Others

Many nations followed the path of the United States, with definitions and criteria for human death that made determination of death by neurologic criteria additive to the current practice of determination of death by circulatory–respiratory criteria, leading to a conceptual duality: circulatory–respiratory or neurologic [32]. A few nations, most notably the United Kingdom, implemented a unified conception of death: "Whatever the mode of its production, brain death represents the stage at which a patient becomes truly dead" [33]. Under this unified conception, loss of

circulatory–respiratory function is only important because of what this signifies to brain function.

If this were the only difference between the US and UK positions, there would be no transatlantic divide, but more a case of "You say tomato, and I say tomahto." The evaluation for death by neurologic criteria would be almost identical in both countries, just with some different flavoring (flavouring). However, this is not the case. The divide is significant, with the United States having legislated that death by neurologic criteria required the loss of *all* functions of the *entire* brain while the United Kingdom identified the loss of brainstem functions as what counted: "It is agreed that permanent functional death of the brainstem constitutes brain death" [34].

It is important to recognize how old the transatlantic divide is. If "[o]ur first problem is to determine the characteristics of a permanently nonfunctioning brain" [27], the Ad Hoc Committee of the Harvard Medical School's answer in 1968 was that "[f]unction is abolished at cerebral, brainstem, and often spinal levels." [27]. Clinically, it was obvious to the Ad Hoc Committee, just as it remains so today, that loss of spinal function was not a requirement for determination of death by neurologic criteria. However, loss of cerebral and brainstem function—anatomically located in the brain—was required. This was supported by the drafters in 1980 of the Uniform Determination of Death Act (UDDA) and approved by the American Medical Association and American Bar Association, where the determination of death by neurologic criteria required "irreversible cessation of all functions of the entire brain, including the brainstem" [32]. Ultimately, this wording made its way into legislation in the majority of states in the United States and in many other countries. Relevant to this chapter's discussion is the prefatory note provided by the drafters defining the "entire brain" and the apparent reasons for this inclusion. The purpose does not appear to be to distinguish the US position from the British brainstem position, but to reject a higher brain criterion for death.

> The 'entire brain' includes the brainstem, as well as the neocortex. The concept of 'entire brain' distinguishes determination of death under the Act from 'neocortical death' or 'persistent vegetative state'. These are not deemed valid medical or legal bases for determining death. [32, p. 3]

In contrast, and as stated above, the UK position is that permanent functional death of the brainstem constitutes the stage at which a patient becomes truly dead, and this was codified in the 1970s. Pallis gave credit for the British support of the brainstem criterion to an earlier individual, Keith Simpson. Simpson was a professor of pathology who, on being asked in 1964 by the Medical Protection Society for a definition of death, proposed the following: "there is life so long as a circulation of oxygenated blood is maintained to live brainstem centres" [14, 35, 36].

So, what is it about the brainstem that led the drafters of the UDDA to specifically identify this part of the brain as part of the entire brain, and led the British to identify permanent loss of this part of the brain as the *sole* criterion for all human death?

The brainstem anatomically houses two essential functional areas of the brain—the *reticular activating system*, an essential component for the generation of consciousness, and the *medulla oblongata* essential for the capacity to breathe. Pallis viewed the loss of consciousness as a reformulation (in terms of modern neurophysiology) of the older cultural concept of the departure of the "conscious soul" from the body and irreversible apnea as the permanent loss of "the breath of life" [14].

So, why privilege consciousness and breathing as the brain functions that count rather than all functions of the entire brain? Many of the arguments used above to privilege brain function over other functions in the body are, in effect, arguments for the privileging of consciousness over other brain functions. They are therefore, in truth, arguments for privileging the brainstem (we explain why below). We have already noted the irreplaceability of the brain. Why? What makes the brain so special that society accepts one can be dead even as other functions in the body can continue? The answer is consciousness. Taking this thought experiment a step further, if one had to choose between losing hormonal function of the brain or consciousness, most would hold to consciousness as the biological function that counts. Just as somatic functions are not equal to brain function, so some brain functions are also not equal—and we find, not unexpectedly, that consciousness reigns supreme.

2 The Coherence that Comes When One Accepts the Brainstem Criterion

Standard textbooks of neurology define consciousness as having two major components: awareness (content) and arousal (wakefulness) [37]. Awareness is identified as a function of the cerebral cortex, whereas arousal relies on a functioning brainstem reticular activating system. Coma, a pathological state marked by deep unconsciousness, typically involves compromised function of the brainstem and other deep brain structures [38]. While it is possible to lose awareness but maintain arousal (e.g., a vegetative state/unaware–wakeful state), loss of brainstem-mediated arousal mechanisms results in simultaneous loss of awareness. Modern textbooks have no difficulty in teaching that intact function of the ascending reticular activating system, with its direct and indirect connections with all levels of the central nervous system, is the basis of, and essential for, any form of consciousness [39, 40]. There is no possibility of the cortex being conscious without the brainstem. This is why the whole-brain criterion is not needed.

Using a computer analogy, the brainstem is like the brain's motherboard. It is what everything else needs to have working so that everything else too can work. However, unlike a computer motherboard, you cannot replace a brainstem. Today, when your brain's motherboard dies, you die. There is no resuscitation possible, and you do not wake up and you do not breathe again.

There is substantial and valid criticism that the insistence in the UDDA on loss of "all functions of the entire brain" does not match clinical practice where patients

determined dead by neurologic criteria are observed to have persistent brain hormonal function (e.g., secretion of antidiuretic hormone), as discussed elsewhere in this book [31, 41]. Some have used the UDDA statement "A determination of death must be made in accordance with accepted medical standards" [32] as a kind of get-out-of-jail clause [42]. If ongoing brain hormone function is in accord with accepted medical standards, then it is not necessary to have all functions of the entire brain be absent. However, this does not work as a legal argument, as we shall see below.

While not doubting the sincerity and capability of the American Academy of Neurology (AAN), there is a type of linguistic gymnastics at play in their position statement:

> The AAN endorses the perspective of the UDDA that brain death has occurred when the irreversible loss of all functions of the entire brain including the brainstem has been determined. However, the AAN endorses the belief that preserved neuroendocrine function may be present despite irreversible injury of the cerebral hemispheres and brainstem and is not inconsistent with the whole brain standard of death. [42, p. 230]

The insistence in the UDDA on absence of "all functions of the entire brain" is strange when no such demand is made of circulatory and respiratory functions. Indeed, the heart itself has a hormonal function. It secretes atrial natriuretic peptide (ANP). Ischemia is known to increase ANP release [43]. Nothing is more ischemic than a failing circulatory and respiratory system. And yet, no doctor has ever paused when determining death using circulatory and respiratory criteria to wonder if the heart has ceased secreting ANP. That is because the only function that matters to the doctor (and the patient) is the pumping function. Were it not for "all functions of the entire brain" being locked into the UDDA and many jurisdictions' legislation, it would seem unlikely that the persistence of brain hormonal functions would even be a matter for discussion and nor would it require the AAN to try and endorse a contrary belief. It is not the AAN that is wrong, but the UDDA.

No such challenge applies to the brainstem criterion, where two functions are accepted as being preeminent above all other functions and anatomically located to the brainstem: breathing and consciousness. The persistence of antidiuretic hormone is no different to persisting atrial natriuretic peptide, or heartbeat, or digestion or any other function in the body.

Even more startling is that the diagnostic tests a doctor might use to determine death in a jurisdiction that insists on the loss of "all functions of the entire brain" are not materially different to the tests used in in the United Kingdom, India, or Canada. All that the AAN standards require by way of a clinical evaluation is an examination to neurologically assess for coma, the absence of brainstem reflexes and apnea, i.e., brainstem functions [44]. The impression that the way the patient cohort has their death determined by neurologic criteria in the United Kingdom, India, and Canada is vastly different from the way the patient cohort has their death determined by neurologic criteria in the United States (and jurisdictions modeled on it) is mistaken. Determining death in patients with isolated brainstem lesions in the United Kingdom is rare, perhaps representing an absolute maximum

of 2% of all cases and, when it does occur, it is worthy of a case report in the primary UK intensive care journal [45]. One of the authors (DG), a neuro-intensive care specialist, vouches that in his own large UK tertiary hospital neuro-intensive care unit, no patient with isolated brainstem lesions has progressed over the last 15 years to the point of even necessitating the consideration of determining death by neurologic criteria. So, in many jurisdictions, the clinical criteria are agnostic between "entire brain" and "brainstem" and any difference that could be present occurs in only a minority cohort of patients. There is, of course, the requirement in some jurisdictions that ancillary or confirmatory tests be used, many of which can demonstrate absence of brain circulation, establishing entire brain involvement [46]. Yet even this difference is less than it appears given that there is evidence that patients with isolated brainstem lesions lose supratentorial blood flow over time [47].

3 Legal Defense

Some societies are more litigious than others, so the number of legal challenges does not necessarily reflect any deficiency in law or guidance. However, the wording in some jurisdictions' determination of death legislation or guidelines can lead them to be more vulnerable to successful legal challenge.

The legal vulnerability of the UDDA is generated because of the adoption of the (1) "all functions" and (2) "entire brain" (whole-brain) criterion [20]. As stated above, the challenge arises largely because not all functions of the brain may have ceased when death is determined by neurologic criteria. As has been pointed out by many, this violates the requirements of the applicable legislation [20, 31, 48]. Some words in statutes are open to differing interpretations, such as the term "reasonable," which can require a judge to ascertain whether, in the circumstances, any impugned conduct was reasonable or not. Words such as "all" and "entire" are not open to interpretation in the same way. Judges cannot decide, for instance, that "entire" does not really mean "entire," or that "all" means "most" or "some."

Excluding mention of all functions of the entire brain criterion in legal statutes and guidance has not protected Canada and the United Kingdom from legal challenge but it certainly has helped, in two ways. First, it is not vulnerable to the objection that some functions, such as hormonal function, remain after death by neurologic criteria. This objection only arises where the law requires the cessation of all functions of the entire brain. Second, the absence of a statute provides much more flexibility. In the Province of Ontario in Canada, there is no statutory definition of death. When a case was brought to the Ontarian courts, the judge was asked to make a common law ruling [20]. Judge Shaw had no difficulty in finding that the 2006 consensus and expert medical guidelines published in the *Canadian Medical Association Journals* [23] represented "accepted medical practice used by all physicians in not only Ontario but throughout Canada to determine death

based on neurologic criteria" [49]. The judge could therefore simply refer to and note the latest medical consensus about the matter raised before her and determine the legal issue accordingly. Judges in the United States, in contrast, are not able simply to find that a determination of death by neurologic criteria was performed in accordance with accepted medical standards and let the matter rest there. They have the additional step of checking that the standards reflect the requirements of the statute. Where current medical practice is out of step with the statutory requirements, there are significant problems and this is precisely what we are seeing in the United States.

In 2015, the Supreme Court of Nevada expressed doubts about whether the AAN standards [44] for determining death by neurologic criteria were authoritative [50]. Following this successful legal challenge in Nevada, the Nevada legislature doubled down and passed legislation stating that the AAN standards are authoritative, and that any subsequent revisions approved by the AAN or its successor organization would also be authoritative [51]. This, however, side-stepped the genuine legal issue that current US clinical practice and AAN guidance do not comply with the legislation [42, 44]. Equally vulnerable to legal challenge are the many jurisdictions that modeled the UDDA in their legislation [20].

The determination of death in the United Kingdom, like in Canada, is also not governed by primary legislation. This makes the legal position in the United Kingdom, too, more flexible because changes in legal guidelines that reflect current medical practice and conceptions of death can be made without the fear of contradicting primary legislation. The United Kingdom is therefore not bedeviled by the problems that we have described with the UDDA in the United States. It is also important to note that the UK courts have specifically accepted the brainstem criterion [20, 52]. In a recent Court of Appeal case in 2020, Patten LJ and King LJ remarked "[t]he courts have, from at least 1992 onwards, accepted the validity of the medical diagnosis arising from an irreversible absence of brainstem function" [53]. Importantly, the recent legal cases have highlighted the importance the common law courts place on the national guidance used in the United Kingdom to determine death [54]. In effect, the common law courts defer to the current applicable national guidance and in that sense confirm their legal force. This is what makes the common law position much more flexible than the position in jurisdictions where the definition of death is governed by legislation, such as the United States.

In a world where experts are increasingly distrusted, our courts and legislators at least still appear to value medical consensus opinion and, when this is challenged, prove supportive. It is just that unlike Canada and the United Kingdom, there are real prospects of successful legal challenge in the United States, given the divergence between medical consensus and the wording of the UDDA. The question is: how do we strengthen the worldwide criterion for the determination of death, so it remains worthy of public trust?

4 The Unfinished Journey to Coherence

Pallis saw clearly that there were two important conceptual steps along the journey to conceptual coherence when determining death [14].

- From classic death ⇨ whole-brain death
- From whole-brain death ⇨ brainstem death

While we can never know for sure, it seems likely that Pallis would be disappointed with how slow the world has been to follow in his steps. Perhaps he might have been pleased with more recent developments, but there is still a long way to go.

In 1998, as inheritors of Pallis's legacy, the United Kingdom Academy of Medical Royal Colleges boldly proclaimed in their Code of Practice for the Diagnosis of Brainstem Death that:

> Death entails the irreversible loss of those essential characteristics which are necessary to the existence of a living human person. Thus, it is recommended that the definition of death should be regarded as 'irreversible loss of the capacity for consciousness, combined with irreversible loss of the capacity to breathe'. The irreversible cessation of brainstem function (brainstem death) whether induced by intra-cranial events or the result of extra-cranial phenomena, such as hypoxia, will produce this clinical state and therefore brainstem death equates with the death of the individual. [55, p. 3]

The successor 2008 UK guidance is very similar in first identifying the functions that count most (breathing and consciousness) and then identifying where one anatomically locates these functions (in the brainstem) [54]. It also endorsed the 1979 unified UK position that ultimately all death, whether from direct brain injury or loss of circulatory or respiratory function, is based on loss of brain function [33, 54].

One may have expected the British brainstem criterion to dominate in Commonwealth nations. However, it is far more mixed than that, almost looking like a lost cause [46]. Australia and New Zealand follow a formulation closely aligned to the UDDA [56]. Likewise, Singapore requires loss of "all functions of the brain" [57]. South Africa leaned heavily on the World Brain Death Project in its recent guidance formulation where previously clinicians were using different available international guidelines, which vary markedly [58]. However, India enacted a law in 1994 which legalized brainstem death [59]. Probably most heartening to Pallis would be that in 2006 Canada moved to the following formulation: "irreversible loss of the capacity for consciousness combined with the irreversible loss of all brainstem functions" [23].

This move in Canada also heralded a distinct shift in the international conceptual debates. Rather than advocating for a criterion focused on "all functions of the entire brain," increasingly proposals are being made for a criterion that emphasizes the functional primacy of "consciousness" and the importance of the brainstem. In

2014, an international consensus development group proposed the following definition for the determination of death:

> Death is the permanent loss of capacity for consciousness and all brainstem functions. [60]

Very similarly, the World Brain Death Project proposed in 2020:

> [Brain death/death by neurologic criteria (BD/DNC)] is defined as the complete and permanent loss of brain function as defined by an unresponsive coma with loss of capacity for consciousness, brainstem reflexes, and the ability to breathe independently. [21]

Although we have emphasized the added flexibility provided when jurisdictions do not have a legislative definition of death, we are not advocating against the use of legislation to define death. If there is legislation already in place, it would seem unlikely the legislation would be repealed rather than amended. However, it is important to be aware of the constraints that legislation can impose when technology in medicine develops rapidly. The legislation can quickly become out-of-date, applicable to technologies and practices that have long since been left behind.

That said, it remains essential that legislation be updated, where problems are caused by outdated wording, to reflect the latest medical position. An example of up-to-date legislation, reflecting the international trend just mentioned, is Nova Scotia. Their legislation may provide some guidance on how the difficulties we have described could be addressed. Nova Scotia used the opportunity in the 2019 Human Organ and Tissue Donation Act to include a definition of death in the legislation [61]. The following statements are made in the Act:

> 2. (g) 'death' means the irreversible cessation of the functioning of the organism as a whole as determined by the irreversible loss of the brain's ability to control and co-ordinate the organism's critical functions;"
>
> "16. The medical tests to demonstrate that death has occurred are those established by the medical profession from time to time. [61]

While an opportunity to make use of the United Kingdom's 2008 and the international consensus development group's 2014 definition was missed in Nova Scotia, the new law did manage to enshrine the crucial point that not all functions in the brain count equally (some are critical) and that it would be the medical profession who would define what functions count as critical by way of their authority to establish the accepted standards of "medical tests to demonstrate that death has occurred."

The UDDA looks increasingly incoherent as we have shown in this chapter; the impact of the UDDA far exceeds the borders of the United States, so the planned revision will have world-wide impact [48, 62]. The responsibility and duty of those who advise on a revision is immense. Table 1 is a summary of the different candidate losses of biological functions the revisers might propose to determine death.

Table 1 Exploring different loss of biological functions as criterion for death

Loss of biological function	Clinical criteria	Criticism/comment
Somatic (whole body) [Ancient and historical criteria]	Rigor Mortis Putrefaction Decapitation	Forensic Historical Not timely (e.g., rigor mortis takes hours, putrefactions days) Indeterminate
Forces in the organism tending to increase entropy irreversibly overcome those that are opposing it [31, 75].	Undefined	Theoretical Impractical Indeterminate
Circulatory–respiratory [76, 77]	Observation period (2–30 min)	Historical Physiologically defined points Reversibility dependent on intention to resuscitate and technology Gray area—ventilated irreversible coma Human centric
Loss of ALL functions of the entire brain [32]	Preconditions Examination brainstem Ancillary investigations (mandatory some jurisdictions)	Physiologically defined points Not all brain functions cease Not-unified to circulatory–respiratory criterion Whole brain Brain centric Human centric
Loss of personhood [Could be used to define those in vegetative states as dead]	Pathology—cortex Ancillary investigations (standard not established)	Inaccurate Residual consciousness Not timely (e.g., vegetative state diagnosed over months) Higher brain Brain centric Human centric
Unresponsive coma with loss of capacity for consciousness, brainstem reflexes, and the ability to breathe independently [21]	Preconditions Examination brainstem Ancillary investigations (mandatory some jurisdictions)	Physiologically defined points Unified Whole brain Brain centric Human centric
"[T]he irreversible cessation of the functioning of the organism as a whole as determined by the irreversible loss of the brain's ability to control and coordinate the organism's critical functions… The medical tests to demonstrate that death has occurred are those established by the medical profession from time to time" [61]	Preconditions Examination brainstem	Critical functions undefined Unified Brain centric Human centric

Table 1 (continued)

Loss of biological function	Clinical criteria	Criticism/comment
Brain injury leading to permanent loss of (a) the capacity for consciousness, (b) the ability to breathe spontaneously, and (c) brainstem reflexes [48]	Preconditions Examination brainstem	Physiologically defined points Not-unified to circulatory–respiratory criterion Brain centric Human centric
Death is the permanent loss of capacity for consciousness and all brainstem functions [60]	Preconditions Examination brainstem	Physiologically defined points Unified Ambiguous if whole brain Brain centric Human centric
"Loss of the capacity for consciousness and the capacity to breathe… The irreversible cessation of brain-stem function… will produce this clinical state" [54]	Preconditions Examination brainstem	Physiologically defined points Unified Brain centric Human centric Consciousness without brainstem?

5 Response to Criticism

As can be seen in Table 1, all the criteria we might choose to accept as a society to determine death are open to criticism. Some are more open to criticism than others. Many of the criteria are vulnerable to the objection that they are brain-centric, and therefore do not accommodate religious and other beliefs [22]. Or they are vulnerable to the criticism that they are human-centric; why, it is asked, should the criterion for death in a human be different than death for a plant or an insect [31]? Such debate is outside the scope of this chapter, but this is discussed elsewhere in this book. The better criteria address the issues raised long ago by the Academy of Science in Paris: how are we to make "the diagnosis of death safe, prompt and easy" [19]? This can be achieved by choosing physiologically defined points that unify the circulatory–respiratory criteria for death with the neurologic criteria for death and, of course, support a hierarchy of brain functions with consciousness at the top and a recognition of the anatomical importance of the brainstem. We consider that the 2008 United Kingdom Code [54] and the 2014 international determination proposal [60] come closest to being the optimal proposal.

There is one standard criticism of death by neurologic criteria that we should dispense with straightaway. This is a criticism of the very idea of a brain-based criterion of death as such, whether it be the whole-brain or the brainstem criterion. On this criticism, influenced by Alan Shewmon, brain-dead people are not dead because the death of the brain does not equate with the loss of the integrated functioning of the organism as a whole. Shewmon correctly showed that many functions in the body are not mediated by, and do not require, a functioning brain, and concluded that a brain-dead person is not dead [29, 63, 64]. No single organ, including the brain, can be the locus of life or death. The death of an *organ* is not the death of an *organism*. There is no difference in principle between the death of a kidney and

the death of the brain [31]. We know this because living people can donate a kidney but remain alive. They could even donate a heart and remain alive, at least in principle (and also, for a time, in reality on a heart-lung machine or ECMO). The death of the brain, it is said, is therefore the death only of an organ, not an organism. Let us call this the Loss of Integrated Functioning View.

However, there is a fundamental problem with the Loss of Integrated Functioning View. It can be flipped over to entail an absurdity. Imagine that the whole of the rest of the body has ceased functioning except the brain, which is kept functioning in the body through external support not making use of any of the other organs in the body. On the Loss of Integrated Functioning View, since an organ is not an organism, someone could have lost all integrated functions and so be dead, yet have retained consciousness [65]. This is an unacceptable conclusion, and decisively shows the inadequacy of the Loss of Integrated Functioning View [30]. Death is brain-based.

More challenging for the brainstem criterion is the question whether consciousness might persist without a functioning brainstem. Pallis was very aware of this potential criticism. So much so that he wrote a limerick about it, referring to decapitations by guillotine during the French Revolution:

> We knit on, too blasées to ask it:
> 'Could the tetraparesis just mask it?
> When the brainstem is dead
> Can the cortex be said
> to tick on, in the head, in the basket?' [12, p. 285]

As we already have discussed, standard neurologic textbooks would say the answer to the limerick is no. Consciousness is both arousal and awareness and both functions require a functioning brainstem. This is why the criticism that under the brainstem criterion a quadriplegic apneic patient who suffered an event rendering them in a persistent vegetative state/unaware–wakeful state (and thereby lacking conscious awareness) would be dead [66], is so misguided [67].

A more recent criticism, by Joffe and Nair-Collins, of the brainstem criterion suggests that it is possible that those with isolated brainstem lesions may satisfy clinical criteria for death, in those jurisdictions which allow it, but still retain the capacity for consciousness. This is because there might be preserved viability and function of parts of the meso-pontine tegmentum (the higher part of the brainstem) [41]. This, the authors claim, can be evidenced by preserved alpha/theta activity on the electroencephalogram. We have already highlighted the rarity of determining death in isolated brainstem lesions, but this criticism is not a criticism against the brainstem criterion per se, but our way of knowing if the brainstem has ceased functioning. It concerns our diagnostic tests, not the criterion. Neither Bouchut in 1846, the Ad Hoc Committee in 1969, nor Pallis in the 1980s thought the job was done in their era; they never thought they had succeeded forevermore in proposing a safe, prompt, and easy way to determine death, but only that they had succeeded given the technology and salient medical practices at the time. If it is found that new tests are required in our death determinations, then we are always learning, and this learning drives us to even greater safety.

What we are learning currently is that the brainstem may have a role so vital we have been underplaying it all these years. Limiting its role in generating a capacity for consciousness to mere arousal—a glorified on/off switch for awareness, the consciousness that counts—reflects a view of the brainstem that is becoming outdated. New neuroanatomical work is identifying the brainstem as the rudimentary seat of all consciousness, i.e., awareness as well as arousal. Bjorn Merker's landmark 2006 paper was entitled "Consciousness without a cerebral cortex: A challenge for neuroscience and medicine" [68]. By reflecting on the emotional and orientating reactions of anencephalic children (for which Alan Shewmon above is acknowledged by Merker), and considering neurologic evolutionary development, Merker came to the startling conclusion that it was the brainstem, not the cortex, which fulfilled the primary function of consciousness "matching opportunities with needs in a central motion-stabilized body-world interface organized around an ego-center" [68]. This finding is in keeping with experimental work on mammals in the early part of the twentieth century [69].[1]

Research by Barron and Klein on insect consciousness is discovering that it is in the brainstem that the most basic level of consciousness is found: the capacity for subjective experience [72]. They argue that subjective experience requires the construction of an integrated neural simulation of the agent in space, allowing an egocentric representation of the world to be built. In humans, the midbrain (part of the brainstem) fulfils this role and analogous structures can be found in insect brains [72]. Our overly simple and minimalistic understanding of the role of brainstem-mediated "arousal" is also being challenged [73].

No one is claiming in any of this recent scientific explosion of output that the cortex is unimportant to human consciousness, only that without a functioning brainstem, there cannot be consciousness anywhere in the brain. What is more, some forms of awareness, and not merely arousal, are anatomically located in the brainstem, not merely the cortex. This emphasizes the foundational role of the brainstem as the anatomical seat of rudimentary consciousness. Where this journey will take us, is yet to be discovered, but we hope Pallis would be pleased that the brainstem will no longer be merely a passenger, but this time, will occupy the driver's seat.

6 Conclusion

We have spent so long divided on whether we need a variant of "the entire brain" criterion or should adopt the "brainstem criterion" that we have forgotten there is more that unites us than divides us. Perhaps this joint statement by Alex Manara, an author of the United Kingdom 2008 Code, and Eelco Wijdicks, an author of the 2010 AAN standard, is a start to bridging the transatlantic debate:

[1] Some have even used Merker to ask the question at the opposite end of life—when is the experience of pain developmentally possible in a fetus [70]. This argument is made more compelling by neuroimaging, highlighting the neglected role the brainstem has for nociception and pain processing [71].

> The perceived divide between whole brain and brainstem death is now kept 'alive' only by a minority. It has more to do with emotive concepts rather than hard neurobiological facts, and represents a failure to accept the centrality of the brainstem in defining life or death. [74]

It would be entirely remiss of us to end this chapter without a limerick in dedication to Professor Christopher Pallis. We cannot vouch for his enjoyment, but we hope he would applaud the sentiment.

To you the mad scientist did bray
On a sad and evil day
For my robot your head
Or your body instead
Where would you be would you say?

You would be in your brain, or as Pallis would say: there can be no consciousness without a functioning brainstem. It's the only coherent position to take.

Declaration

Dr. Gardiner is Associate Medical Director—Deceased Organ Donation for NHS Blood and Transplant, the national organ donation organization in the United Kingdom. The views expressed are his own.

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