The lucid interval associated with epidural bleeding: evolving understanding

Historical vignette

JEREMY C. GANZ, M.A., PH.D., F.R.C.S.
Ulverston, United Kingdom

The aim of this paper was to elucidate the evolution of our understanding of the term “lucid interval.” A number of texts were reviewed to assess their suitability for analysis. The primary requirement was that the text contain detailed descriptions of a series of patients. Details of the clinical course, the findings and timing of surgery, and, when relevant, the time of death and postmortem findings were required. Books written by Henri-François Le Dran, Percival Pott, and James Hill fulfilled these criteria. Surgical findings included the presence and type of fractures, changes in the bone, separation of periosteum, malodorous or purulent material, tense brain, and hematoma. Postmortem findings supplemented and/or complemented the surgical findings. The courses of the patients were then tabulated, and the correlation between different clinical and operative findings was thereby determined.

Our understanding of a lucid interval began in the early 18th century with the work of Henri-François Le Dran and Percival Pott in London. They did not, however, demonstrate an interval without symptoms between trauma and deterioration in patients with epidural hematomas (EDHs). The interval they described was longer than usually expected with EDHs and occurred exclusively in patients who had a posttraumatic infection. In 1751, James Hill, from Dumfries, Scotland, described the first hematoma-related lucid interval in a patient with a subdural hematoma. The first case of a lucid interval associated with an EDH was described by John Abernethy. In the 19th century, Jonathan Hutchinson and Walter Jacobson described the interval as it is known today, in cases of EDH. The most recent work on the topic came from studies in Cincinnati and Oslo, where it was demonstrated that bleeding can separate dura mater and that hemorrhage into the epidural space can be shunted out via the veins. This shunting could delay the accumulation of a hematoma and thus the rise in intracranial pressure, which in turn would delay the development of symptoms.

The lucid interval as previously conceived was not properly understood by the French school or by Percival Pott and Benjamin Bell, who all described a symptom-free period prior to the development of infection. The first to have a proper understanding of the interval in relation to an EDH was John Abernethy. The modern description and definition of the lucid interval was the work of Hutchinson and Jacobson in the latter half of the 19th century. Understanding of the pathophysiology of the lucid interval has been advanced by the work of Ford and McLaurin in Cincinnati and a group in Oslo, with the demonstration of what it takes to loosen dura and how an arteriovenous shunt slows down for a while the accumulation of an EDH.

(http://thejns.org/doi/abs/10.3171/2012.12.JNS121264)

Key Words • lucid interval • Percival Pott • Henri-François Le Dran • John Abernethy • Jonathan Hutchinson • Walter Jacobson • history

The association between epidural bleeding and a lucid interval between trauma and deterioration is familiar. It is also generally believed that the concept originated in the French school at the Académie Royale de Chirurgie in Paris in the 1730s. However, on reading texts from that time it would seem that the lucid interval as we understand it today—as a period without symptoms, lasting from a few hours to a few days—was not what the earliest authors described. It would take more than a century before a modern understanding was reached. The purpose of this paper was to trace the evolution of the understanding of the lucid interval. This conception necessarily depends on an awareness of the mechanisms of post–head injury symptoms, so the progression of the understanding of these symptoms is also presented.

Before 1730

In classical times, Celsus wrote, “We must enquire whether the patient has had bilious vomiting, whether there has been obscuration of vision, whether he has become speechless, whether he has had bleeding from the nose or ears, whether he fell to the ground, whether he has lain senseless as if asleep; for such signs do not occur unless with fractured bone.” Celsus also introduced the notion that the relevant symptoms could be related to torn meninges: “[I]n addition there is also stupor, if the mind wanders, if either paralysis or spasm has followed.

Abbreviation used in this paper: EDH = epidural hematoma.
it is probable that the cerebral membrane has also been lacerated.24 Thus, the symptoms were variously attributed to damage to the bone or meninges. In addition to the above, Celsus was aware that bleeding could occur without a fracture: “Rarely, but now and then, it happens, however, that while the bone remains whole and sound, yet within the skull a blood-vessel in the cerebral membrane has been ruptured by the blow and some blood has escaped, and this having formed a clot, causes great pains, or sometimes obscures vision.”25 His writings had great authority right down to the 18th century, when his ideas began to be challenged.

In more recent times the possibility that extravasation of blood could occur and be a danger with or without a fracture was known to Richard Wiseman (1622–1676), surgeon to the Royalists in the British Civil War and later surgeon to King Charles II.25 He stated, “Concussions of the Brain . . . wherein symptoms arise to a great Height without breaking either the Skin without, or Scull within . . . if of the greater Sort with Rupture of the Vessels, and extravasation of Blood, they produce Stupores, Vertigines, Deliria, and many like Symptoms, and are every whit as dangerous, nay often more dangerous than Fractures themselves.”25 Wiseman believed the brain to be “insensible” because he observed that brain fragments in a wound were not associated with any clinical disturbance. Thus, he believed the aforementioned symptoms came from meningeal damage in keeping with Celsus’ authority.

Daniel Turner (1667–1740) defined such symptoms as “conjectural . . . because it is very possible the same Symptoms may happen to supervene upon Concussion only of the Brain, with Effusion of Blood upon its Substance, yet without a Fracture.”24 Samuel Sharp (c1700–1779) in 1733 wrote: “Fractures of the Scull are at all times very dangerous, not in consequence of the Injury done to the Cranium itself, but as the Brain becomes affected either from the Pressure of the fractur’d Bone or that of the extravasated Blood and Matter. If then the Symptoms which excite by a Fracture do sometimes follow from a mere Extravasation of Blood . . . it must likewise happen that a Rupture of the Vessels of this part, without a Fracture will occasion the same disorders.”25 These distinguished surgeons all understood an extravasation of blood could occur with or without a fracture and that such extravasations were dangerous. Nonetheless, their understanding was partial in that they did not realize the true origin of the symptoms and left no record of successful therapy for such extravasations. The first advance in the 18th century was distinguishing the brain as the source of these relevant symptoms. However, before proceeding to the main part of this paper, it is necessary to be clear about certain elements of terminology where 18th century usage differs from our own.

18th Century Medical Usage

Concussion

The definition of “concussion” seems to have been applied to any degree of brain disturbance due to trauma. A later example of this usage comes from the works of John Bell. In a section subtitled “Concussion” in his book The Principles of Surgery, Bell quotes the postmortem findings of a case of John Abernethy’s. The patient had fallen from a height “of at least eighty feet.” There was no mark of trauma on his head. His clinical description includes the following: “his fall broken by touching the ground first with his wrist, which was dislocated and mangled; his forehead next struck the ground, and his face was bruised, but his cranium was uninjured.”26 The patient died and underwent an autopsy, and part of the report reads as follows:

The minute arteries of the pia mater were turgid with blood; in many places there was the appearance called blood-shot, which was also to be seen in the lining of the ventricles. Dark-colored, and in some places bloody, coagulable lymph filled all the recesses between the tunica arachnoidea and pia mater. On dividing the substance of the brain, all its vessels appeared as if injected with blood.

This is obviously a condition we would consider more as contusion than concussion, and the distinction needs to be born in mind. It should also be noted that the terms “commotion” and “commotio cerebri” were used as alternatives to “concussion.” The whole understanding of the terminology is confusing when viewed from the point of view of the 21st century, and a more detailed analysis is considered to be outside the range of the current paper.

Inflammation

The clinical picture of rubor, calor, tumor, and dolor was familiar. The pathophysiology was not. Thus, the term “inflammation” may be used in an imprecise manner, and its interpretation needs care.

Matter

“Matter” refers to any abnormal material lying within a field of observation. One must be careful about assuming that it is infected. However, if the word “putrefaction” or “purulent” is used or reference is made to a malodorous material, it seems reasonable to believe that the substance under advisement was infected.

Académie Royale de Chirurgie

The surgeons of the Académie Royale de Chirurgie, led by Jean Louis Petit, were the first to report the importance of timing in the development of symptoms after head trauma. Petit’s work was first published in 1774, after his death, and these ideas were first made available to a wider audience by Henri-François Le Dran (1685–1770). Le Dran was a close colleague of Petit, and his own work was published in English in 1740.19 Le Dran must have greatly impressed the London medical and scientific milieu because he was awarded a Fellowship of the Royal Society on January 10, 1745.22 The first crucial statement concerned the source of the symptoms. He wrote,

Must the Loss of Sense, which happened at the Moment the Blow was given, be looked upon as a Symptom of the Fracture? No because it continued only Half-a-quarter of an hour, the Fracture remaining in the same Condition for the space of a whole Day, without being dressed. Is it a Symptom of the Dura Mater’s being lacerated? It is not, for the same
The lucid interval with epidural bleeding

This is the first clear statement that posttraumatic symptoms came from damage to the brain. It was moreover at pains to demonstrate that the damage to the meninges could not be the cause of symptoms either: “Is it a Symptom of the Dura Mater’s being lacerated? It is not, for the same Reason.”

The second contribution from the Paris school was their burgeoning understanding of the timing of the appearance of symptoms. “Therefore, altho’ there had been no Interval between the Loss of Sense, which is the Symptom of a slender Concussion, and the Lethargy or Coma, which properly belongs to an Extravasation in some Part or other, I believe they must be distinguished in the Imagination, tho’ they are often confounded; and I dare venture to affirm, that was it possible an Accident of this Nature could happen without the least Concusson, no sudden Loss of Sense would have ensued, and the Lethargy would have followed some Minutes after the Blow; that is to say, when the Dura Mater and the Brain suffered a Compression.” A little later Le Dran states “that the Coma or Lethargy (the Consequence of an Extravasation) so closely follows that of the Concussion, as to make us confound one with the other.”

There is thus an understanding that symptoms of concussion are immediate while those of compression come later, though the two sets of symptoms can run into each other. However, there is no clear statement that there was a proper lucid interval in association with an EDH. In Le Dran’s series only 2 patients who underwent trepanning had a period of mental clarity in the first 24 hours. These patients were featured in Observations XVII and XXV. Both patients died of infection. Neither had an EDH. Observation XIX concerned a patient who successfully underwent surgery for an EDH. This patient had no lucid interval, and the indication for surgery was persistent coma.

In conclusion, the Paris school understood that the relevant symptoms came from damaged brain and that there could be an interval between trauma and the symptoms of extravasation. However, there is no description of a period without symptoms during this interval. Rather there is a description of immediate symptoms running into deteriorating symptoms. The importance of epidural bleeding was emphasized since hemorrhagic extravasation between cranium and dura as the source of concern is mentioned on 12 occasions, whereas subdural hemorrhagic extravasation is mentioned only twice. Thus, Le Dran clarified the difference between immediate and delayed symptoms, but he did not describe a lucid interval.

Percival Pott

Sir Percival Pott (1714–1788) wrote with great clarity. Here is his expression of the relationship between brain and symptoms: “What are the symptoms of a fractured cranium? is often asked; and there is hardly any one who does not, from the authority of writers, both antient [sic], and modern, answer, vomiting, giddiness, loss of sense, speech, and voluntary motion; . . . This is the doctrine of Celsius.” He goes on to state that these symptoms “can only be the consequence of an affection of the brain as the common sensorium. They may be produced by its having been violently shaken, by a derangement of its medullary structure, or by unnatural pressure made by a fluid extravasated on its surface or within its ventricles.” He says elsewhere that “[a] concussion and an extravasation are very distinct causes of mischief, though not always distinguishable” and, later on the same page, that “[t]he loss of sense which immediately follows the violence, say they, is most probably owing to the commotion; but that which comes on after an interval of time has past, is most probably caused by extravasation.”

This is unambiguous. It is followed by a repetition of Le Dran’s concerns that the severity of a concussion or the speed of development of an extravasation may result in the two clinical disturbances merging into one another. Pott was aware that interpreting clinical findings was not a clear matter. He states, “We not only have no certain infallible rule, whereby to distinguish what the pressing fluid is or where it is situated, but we are in many instances absolutely incapable of knowing whether the symptoms be occasioned by any fluid at all; for a fragment of bone, broken off from the internal table of the cranium, and making an equal degree of pressure, will produce exactly the same complaints.”

Thus, Pott had the same understanding of immediate symptoms due to concussion and delayed symptoms due to extravasation. However, like Le Dran he observed no symptom-free lucid interval. There are 3 EDHs in Pott’s 43 cases. None of these 3 cases had a lucid interval. One patient (Case 34) was not surgically treated because there was no indication of where the trephine should be set and the diagnosis was made postmortem. The patients in the other 2 cases (Cases 35 and 36) both underwent trepanning and both survived. One patient (Case 35) was surgically treated following persistent coma with the appearance of a small swelling on the 5th day, which was considered a guide to the placement of the trephine. The second patient (Case 36) was also surgically treated following persistent coma again with the appearance of a swelling on the 4th day, indicating where to operate. Thus, it would seem for Pott as for Le Dran that compression resulted in delayed deterioration, but there was no real clear-cut description of a symptom-free interval followed by deterioration associated with epidural bleeding.

He emphasized that his concern for hemorrhagic extravasations was, in practice terms, limited to epidural bleeds, and here he was also concerned about the state of the blood: “Extravasations of any kind . . . are very hazardous . . . but considered relative to the art of surgery, that which consists of merely fluid blood situated between the cranium and the dura mater is certainly best, as it is nearest the surface, and admits the greatest probability of being relieved by perforation of the skull; grumous or coagulated blood, although in the same situation, by being most frequently adhering to the membrane, is not so readily discharged as the preceding, and therefore more likely to prove destructive.”

Nonetheless, for Pott there was a group of cases in which any initial cerebral disturbance was followed by days of normality, which in turn were followed by dete-
roration. However, this picture was not related to extravasation but to infection. The patients in 14 of his cases died of infection. In this situation he is very precise about two things. The clinical picture was quite different from that in concussion/extravasation. The symptoms were “all of the febrile kind; and never, at first, imply any unnatural pressure: such as pain in the head, restlessness, want of sleep, frequent and hard pulse, hot and dry skin, flushed countenance, inflamed eyes, nausea, vomiting, rigor; and toward the end convulsion and delirium. And none of these appear at first; that is, immediately after the accident; seldom until some days have past . . . and seldom affect the organs of sense until the latter end of the disease; that is, until a considerable quantity of matter is formed, which matter must press like any other fluid.”

In Pott’s cases there are repeated descriptions of putrefaction and malodorous fluids and materials, indicating that these were infected cases. A more detailed account of the clinical course and outcome in these patients can be found elsewhere. Thus, while the symptoms developed after a latent course and outcome in these patients can be found there are repeated descriptions of putrefaction and malodorous fluids and materials, indicating that these were infected cases. A more detailed account of the clinical course and outcome in these patients can be found elsewhere.

In summary, Pott was very clear that brain damage, whether from concussion or compression, was the source of symptoms after a head injury. He was aware of the potential significance of a delay in deterioration as an indicator of extravasation rather than concussion but found it could all too easily merge with concussion symptoms. The extravasations that interested him were like those of Le Dran’s epidural bleeding. He made no attempt to quantify the relevant duration of the interval, and he experienced no EDH with a symptom-free lucid interval.

James Hill

James Hill (1703–1763) recorded the first mention of a genuine lucid interval in the fourth case in Chapter 2 of his book *Cases in Surgery*. The injury occurred in 1750 and concerned a girl who fell off her horse and then walked home. She suffered subsequent amnesia and was then better for a couple of days. She was troubled with progressive headache and vomiting, which progressed in intensity, but her parents refused surgery. Finally, after 5 weeks she insisted on an operation. At trepanation, there was no EDH, but there was partly coagulated black liquid blood under the dura. Her recovery began immediately after surgery. Thus, the first recorded case of a proper symptom-free lucid interval was associated with a subdural hematoma and not an EDH.

Benjamin Bell

Benjamin Bell (1749–1806) hailed from Dumfries, where his early training was undertaken by the same James Hill mentioned above. He was to progress in Edinburgh and be influenced by some of the most celebrated medical men of his day. He was a controversial figure not least because of criticism from his namesake (although no relative) John Bell (1763–1820), the cantankerous elder brother of the more famous Charles Bell (1774–1842). Benjamin Bell and John Bell found themselves on opposite sides of a local medical political divide in Edinburgh. Benjamin Bell’s textbook *System of Surgery* was influential and a commercial success. He has been credited with advancing the concept of the lucid interval, although this is, in fact, not the case. He just describes again the delayed infection that is seen in the work of both Pott and Le Dran. There is nothing in his *System of Surgery* to show he understood the time element separating concussion and compression. Moreover, there is absolutely no mention of a symptom-free lucid interval between injury and deterioration. Indeed, a major weakness of his work is the absence of any of the sort of case histories that illustrate and illuminate so much of the writings of his predecessors.

John Abernethy

John Abernethy (1764–1831) described 3 cases of epidural bleeding. Abernethy, the son of a well-to-do clergyman, was of Scottish Irish ancestry. He was initially trained by an incompetent surgeon called Sir Charles Blucks. Thereafter, he was influenced by Sir William Blizzard at the London Hospital, to whom he dedicated his book in which the 3 cases are described. He was one of the distinguished London surgeons later influenced by another expatriate Scotsman: John Hunter. Abernethy described a series of 17 cases of head injury. Case VII was a man knocked down by the hook of a crane. He was stunned but then got up and walked home and put himself to bed. Later that same day a surgeon was called, as the man was unconscious. He was surgically treated, and a large EDH was found; after removal of the EDH, the brain did not reexpand and the patient died. This is a description of a genuine lucid interval. The patients in the other 2 cases did not wake up after the trauma. Abernethy maintains the view that “[i]t seems then that extravasation between the dura mater and the cranium is almost the only case which admits of being remedied by the use of the trephine.” He had little faith in the possibility of treating subdural hematomas. Comments following the case reports of epidural bleeding include, “But if the fracture happens in the track of the principal artery of the dura mater, if the trunk or even a considerable branch of that vessel be torn, the haemorrhage will be profuse, and the operation of the trephine become immediately necessary to preserve the life of the patient.” It is implied but not stated that this bleed is ongoing with a posttraumatic increase in hematoma volume. This is the likely interpretation since the first patient had a lucid interval.

Charles Bell and John Abernethy

Abernethy and Charles Bell (1774–1842) became involved in a passionate debate about the pathophysiological background of the lucid interval. Bell was the fourth son of an Episcopalian minister in Edinburgh. He claimed he received all his basic education from his mother. His surgical education he received largely from his elder brother John. However, George Bell, who was
The lucid interval with epidural bleeding

older than Charles but younger than John, advised him to travel to London, as John’s quarrelsome nature had made him sufficiently unpopular that it could have affected Charles’ career in Edinburgh. Thus, Charles became yet another Scot to have a profound effect on the development of medical science in the English capital. Bell would not accept Abernethy’s implied contention that ongoing bleeding from a middle meningeal artery could lead to an increase in hematoma volume. He begins by stating of Abernethy, “It will appear no doubt remarkable that he should display on many occasions such vigour of intellect and close reasoning, which have been attended with great improvements, and on this take so much for granted, and convey an advice so full of danger.” He continues a little later, “I might say it is extraordinary that any one who has ever raised the skull-cap in dissection, and felt the strength of the universal adhesions of the dura mater to the lower surface of the bone, could for an instant believe that the arteria meningea media has power of throwing out its blood, to the effect of tearing up these adhesions from the entire half of the cranium!” Bell then recounts an elegant experiment in which he struck a head with a mallet. He then injected size (a fluid wax that sets once cooled) up the arteries of the head demonstrating a “clot” of size under the location of the blow. He deduces not unreasonably that the blow has separated the dura from the bone and concludes that “the extravasation of blood is a consequence and not the cause of the separation.” He later makes the crucial quantitative contribution: “[y]et it is a remarkable fact that the modern annals of surgery do not, as far as I am aware, contain any cases in which in this obituary is his unique contribution to neurosurgery mentioned. He wrote a monograph on epidural bleeding entitled “On Middle Meningeal Haemorrhage” in Guy’s Hospital Reports. This monumental monograph catalogued all current knowledge of and therapeutic endeavors for this potentially treatable bleed. He recorded the results for 70 patients, of whom 13 survived. (He does not include the patient of Le Dran who was surgically treated in 1708 and survived.) He found that the earliest successfully treated cases were those handled by James Hill in Dumfries. The patients were surgically treated in 1751 and documented in 1771 with a long follow-up and high-quality survival. These cases occurred more than 60 years before any other successful report featured in Jacobson’s paper.

Jacobson described the clinical picture in detail, but he paid special attention to the lucid interval. He stated that “[i]t will be seen that out of sixty-three cases of middle meningeal haemorrhage in which the interval of lucidity is mentioned – In 32 it was well marked. In 10 it was but little marked and might have been overlooked. In 21 it was absent.” With regard to the duration of the interval, in Jacobson’s material it lasted from a few minutes to several hours. However, there is a footnote referring to an article by a Dr. P. Wiesman of Zurich whose paper contained 278 cases and a lucid interval that varied from 15 minutes to 4 days. Jacobson also seems to accept Abernethy’s mechanism for the lucid interval while understanding the importance of Bell’s explanation of dural separation. He states, “The duration must depend upon the size and number of the branches of the middle meningeal which are opened, it making all the difference whether one or two large branches are opened by the fracture, or by a number of minute ones torn by the violence which separates the dura from the bone. The rate at which blood is poured out, as well as its amount, will also influence the duration of the interval.” Jacobson also emphasized that when the lucid interval was absent, it might well be due to the mechanism previously mentioned: “The concussion . . . passed straight into the compression.” However, he also mentions for the first time the importance of drunkenness in obscuring the lucidity. He thinks it is especially important given the frequency of drunkenness.

In conclusion, Jacobson had come as far as he could with the information available to him, and his clinical analysis and explanations have remained mostly accepted up to the present day. The modern definition and characteristics of the lucid interval were established. Further developments in the understanding of the mechanism behind the lucid interval would have to wait until after the Second World War.

Jonathan Hutchinson

Jonathan Hutchinson (1828–1913) finally described the lucid interval in terms that are familiar today: “The importance of an interval of immunity between the accident and the occurrence of symptoms has long been recognized as the chief indication of a ruptured meningeal artery; and it is to this, almost exclusively, that we must give attention, if we wish to diagnose these cases.” He later makes the crucial quantitative contribution:

The period at which the haemorrhage occurs may vary in these cases, just as it may after wound of an artery in one of the limbs. It is rarely profuse at first enough to cause symptoms. It may increase in the course of a few hours, or it may burst out suddenly, as a sort of secondary haemorrhage, at the end of one or two days afterwards. In rare instances it may even be delayed for a week.

He notes that the results of surgery for EDH are dismal, “[y]et it is a remarkable fact that the modern annals of surgery do not, as far as I am aware, contain any cases in which life has been saved by trephining for such a state of things.”

In conclusion, Hutchinson sums the experience of the previous century with a modern clear definition of the lucid interval. He appears to have agreed with Abernethy as regards the mechanism underlying the lucid interval.

Walter Hamilton Acland Jacobson

Walter Jacobson (1847–1924) was the son of a priest in Oxford who became Professor of Divinity and ultimately Bishop of Chester. He was educated at Winchester and Corpus Christi College Oxford, graduating with first class honors in 1869, as recorded in his obituary. No-one in this obituary is his unique contribution to neurosurgery mentioned. He wrote a monograph on epidural bleeding entitled “On Middle Meningeal Haemorrhage” in Guy’s Hospital Reports. This monumental monograph catalogued all current knowledge of and therapeutic endeavors for this potentially treatable bleed. He recorded the results for 70 patients, of whom 13 survived. (He does not include the patient of Le Dran who was surgically treated in 1708 and survived.) He found that the earliest successfully treated cases were those handled by James Hill in Dumfries. The patients were surgically treated in 1751 and documented in 1771 with a long follow-up and high-quality survival. These cases occurred more than 60 years before any other successful report featured in Jacobson’s paper.

Jacobson described the clinical picture in detail, but he paid special attention to the lucid interval. He stated that “[i]t will be seen that out of sixty-three cases of middle meningeal haemorrhage in which the interval of lucidity is mentioned – In 32 it was well marked. In 10 it was but little marked and might have been overlooked. In 21 it was absent.” With regard to the duration of the interval, in Jacobson’s material it lasted from a few minutes to several hours. However, there is a footnote referring to an article by a Dr. P. Wiesman of Zurich whose paper contained 278 cases and a lucid interval that varied from 15 minutes to 4 days. Jacobson also seems to accept Abernethy’s mechanism for the lucid interval while understanding the importance of Bell’s explanation of dural separation. He states, “The duration must depend upon the size and number of the branches of the middle meningeal which are opened, it making all the difference whether one or two large branches are opened by the fracture, or by a number of minute ones torn by the violence which separates the dura from the bone. The rate at which blood is poured out, as well as its amount, will also influence the duration of the interval.” Jacobson also emphasized that when the lucid interval was absent, it might well be due to the mechanism previously mentioned: “The concussion . . . passed straight into the compression.” However, he also mentions for the first time the importance of drunkenness in obscuring the lucidity. He thinks it is especially important given the frequency of drunkenness.

In conclusion, Jacobson had come as far as he could with the information available to him, and his clinical analysis and explanations have remained mostly accepted up to the present day. The modern definition and characteristics of the lucid interval were established. Further developments in the understanding of the mechanism behind the lucid interval would have to wait until after the Second World War.
Pathophysiology of the Lucid Interval

Secondary Dural Stripping After the Initial Trauma

The initial crucial finding concerning dural stripping came from the work of Ford and McClaurin in 1963. They conducted experimental work in dogs, and while the findings cannot be uncritically transferred to humans, the principles should hold good. The key findings were that if an adequate area of dura is separated from the skull (in dogs, only an area 6–8 mm in diameter), then the arterial pressure from a ruptured middle meningeal artery has adequate force to effect further loosening of the dura from the skull. Thus, Abernethy was right. Since a certain amount of dura must be loosened before further loosening can occur, Bell was also right. It would appear to be very unlikely that bleeding into the epidural space from a vein can produce any further stripping of dura, since venous bleeding could never generate enough force to strip dura from the skull. This finding is still not fully appreciated, with authors of some recently published articles believing a venous tear can cause an EDH. The more probable reality is that in nonsurgically treated cases, bleeding from a torn vein may well fill a cavity produced by loosening the dura but cannot expand the volume. Alternatively, in surgically treated cases, further bleeding may occur from a torn vein or sinus at surgery. This may well be due to the ability of torn veins to bleed once the rigid container of the skull has been opened and resistance to bleeding has been thereby reduced.

Shunting Blood From the Epidural Space

In a series of papers from Oslo in the late 1980s it was demonstrated experimentally that blood entering the epidural space could run out of it again via the veins. The epidural space of course exists only when trauma to the skull has been opened and resistance to bleeding has been thereby reduced.

Conclusions

The lucid interval as previously conceived was not properly understood by the French school and by Percival Pott, who described a symptom-free period prior to the development of infection. The first to have a proper understanding of the interval in relation to an EDH was John Abernethy. The modern description and definition of the lucid interval was the work of Hutchinson and Jacobson in the latter half of the 19th century. Understanding of the pathophysiology of the lucid interval has been advanced by the work of Ford and McClaurin in Cincinnati and by a group in Oslo, with the demonstration of the mechanism by which dura is loosened and how an arteriovenous shunt slows down for a while the accumulation of an EDH.

Disclosure

The author reports no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Acknowledgment

The author thanks Professor Ian MacIntyre of Edinburgh for his many helpful suggestions, his careful reading of the manuscript, and his lucid analysis of its contents.

References

1. Abernethy J: Section II. Injuries of the head attended with extravasation of blood upon the dura mater, in Surgical and Physiological Essays. Part III. London: Cadell and Davies, 1979, p 31–32
7. Flamm ES: From signs to symptoms: the neurosurgical management of head trauma from 1517 to 1867, in Greenblatt SH, Spencer. Fractures of the Limbs, Tumors, the Operations of Trepan and Lithotomy. Vol II. London: Tegg, 1826, p 332

J. C. Ganz

J Neurosurg / Volume 118 / April 2013
The lucid interval with epidural bleeding

19. Le Dran HF: Observations in Surgery; Containing One Hundred and Fifteen Different Cases; With Particular Remarks on Each, for the Improvement of Young Students. Translated by J. Sparrow. London: J Hodges, 1740

24. Turner D: The Art of Surgery: In Which is Laid Down Such a General Idea of the Fame, as is Founded Upon Reason, Confirmed by Practice, and Further Illustrated With Many Singular and Rare Cases Medico-chirurgical. Vol II. London: Rivington and Clarke, 1736, p 194

Accepted December 4, 2012.
Please include this information when citing this paper: published online January 18, 2013; DOI: 10.3171/2012.12.JNS121264.
Address correspondence to: Jeremy C. Ganz, M.A., Ph.D., F.R.C.S., 53 Market Street, Ulverston, Cumbria, LA12 7LT, United Kingdom. email jcganz@gmail.com.