The development of a new technology usually starts with an idea of how to solve a problem. If that problem is one that is, or becomes, widely accepted as an important one, deserving of solution, and if the idea can realistically and efficiently be implemented through currently and readily available means, a new form of technology may emerge.

In today’s world of highly complex technology, the devices that enable practitioners to implement their techniques are rarely manufactured by a practitioner. Because of the high cost, in both money and labor, that eventual production demands, manufacturers rarely make a device available unless they believe that it will be widely accepted (and purchased) in a competitive market.

Bronze instruments, recently unearthed in Pergamon, show what appears to be an oral suction device on one end and a tip on the other end, which bears a strong resemblance to the tip of a modern cataract-extraction device. It is believed that the 2nd century A.D. Roman physician, known as Galen, used these for just that purpose at that time. Presumably, it would not have been that hard for a respected physician (particularly if he were the chief physician for the emperor’s gladiators) to request a local metalworker to fashion such a simple device. In today’s market, that might be much more difficult.

In the 21st century, new devices are generally much more complex and, hence, much more expensive than those made in the 2nd century. Accordingly, a substantial and realistically dependable market must be established before any company would undertake such an endeavor.

Although these unearthed devices make it evident that cataract extraction was at least attempted in the ancient world, it did not seem to flourish as a surgical treatment in the ensuing years, and the technique did not realistically become commonplace until the 21st century. A discussion of those factors that facilitate or hinder the wide acceptance and development of new technology is the substance of this paper.

To illustrate the interplay of factors involved in the rise, decline, and eventual renaissance of certain functionally related technologies, we examine 2 technologies. As the first example, methods for opening the human cranium without damaging the underlying structures are examined, from prehistoric trephination through modern craniotomy. As the second example, a very short-lived radiographic technique for the demonstration of an axial view of the lumbar spine is examined.
outlining a larger disk, which was then tapped out and removed. Some of these trephinations were occasionally so extensive as to resemble a 21st century decompressive craniectomy or trauma flap.

One of the more ingenious techniques has long been attributed to the Incas of the Peruvian highlands but was probably developed by more coastal tribes, many centuries earlier. This involved the “tumi,” a more or less hemispheric blade attached to a perpendicular handle that could be rocked back and forth, creating a cut through the bone, which could be repeated in a rectangular (or tic-tac-toe) fashion, allowing a central rectangle to be cut out and removed. What is ingenious about this technique is that the wide curve of the blade allowed a long enough cut to be made in the bone before the device could penetrate very far. Hence, it was much more difficult to “plunge” with this instrument than with others, with the possible exception of the simple scraping of a rough stone, a technique that was presumably extraordinarily inefficient and time consuming.

Cookie cutter–like circular trephinations were subsequently practiced, almost continually, from as early as the Hellenistic period onward. These were usually created with a short cylindrical device that had a long handle on one end and serrations on the other. The long handle was rapidly rotated using either the surgeon’s opposing palms or, more often, a bow (Fig. 1). Although the circumferential engraving on these cylinders might have offered some protection against plunging, the straight design must have been less reliably safe than the tumi.

In certain late Medieval and Renaissance manuscripts, one notes a new device for “powering” these trephines, one that was more or less functionally indistinguishable from a 20th century Hudson brace. At roughly the same time (but not necessarily in the same manuscripts), there appeared a tapering sheath for the perforating drill, which would presumably effect a safety feature similar to that created by a tumi.

Interestingly, straight cylindrical perforating trephines were frequently, if not routinely, seen in surgeons’ instrument cases as late as the American Civil War. The tapered cylinder was also frequently seen, but not universally (Fig. 2).

Again, as late as the American Civil War, most trephines were powered by a T-shaped handle, perpendicular to a short staff, which extended up from the cylinder. The Hudson brace–like device seemed to fall out of use, until the early 20th century. At that time, the tapered trephine began to be replaced by a perforator drill bit that was used to create a bur hole with the subsequent application of a round bur drill bit (Fig. 3). The initial perforation was made with a tapered device that had a gradual incline, somewhat similar in concept to the tumi (Fig. 4). This is often referred to as the Cushing perforator, although it is more correctly named the Doyen perforator.
To create a larger craniotomy than the trephine could effect, bur holes were connected with cuts between each of them. Although we generally think of this as a 20th century technique, there is evidence that Galen performed such procedures in the 2nd century. Again, this evidence consists of unearthed bronze instruments, to which we will return subsequently.

During the last 2 decades of the 19th century and the first 2 decades of the 20th century, bur holes were connected using a multitude of techniques. Hatchet-shaped, serrated saws, such as the Hey saw, were used, but these offered little or no protection from plunging (Fig. 2). Surgical skill and care were the necessary prerequisites. Rongeurs, such as the Montenovesi forceps, were used, but these were, no doubt, clumsy and depressed the dura mater and underlying brain, if not actually damaging them (Fig. 5).2

Multiple permutations on the theme of a circular saw cutting through the bone over a metal guard, protecting the dura, were used but none remained in the mid- and late 20th century neurosurgical armamentarium (Fig. 6).1,4,8,9 By far the most efficient device for the task in question has been the barbed wire—like saw invented by Dr. Gigli for use in cutting the symphysis pubis in cases of dystocia. Adapted for use in the skull, this has been the most reliably effective instrument to appear.9

Nevertheless, one of the previously mentioned mechanical devices stands out and has, in a slightly different form, remained alive. Moreover, its direct lineage extends
back nearly 20 centuries. In 1897, a dentist named Matthew Cryer published a description of a small button on the bottom of a post, on which a rotating saw rested. The design was absolutely indistinguishable from a modern craniotome (such as the Midas Rex) (Fig. 7).1,9 Interestingly, a device consisting of a rotating saw attached to a distal button without a supporting arm was also known and was called a “frise” (Figs. 8 and 9).4,9

Even more surprisingly, a supporting arm, ending in the button and bearing a sharp edge on the inner surface of the arm, was fashioned in bronze and is seen in what is thought to be the armamentarium of Galen, in the 2nd century. Presumably, this was hammered from trephination to trephination, using a mallet (Fig. 10).11

An evaluation of the aforementioned chronology suggests certain trends. If we review the different methods of initial perforation, we find that only the tumi exhibited the significant safety feature of a tapered approach, until, that is, the advent of the device seen in Renaissance manuscripts. Note that this appeared at approximately the same time as the increased “power” of the Hudson brace-like device.

As most neurosurgeons can attest, even without the white plastic safety guard on modern twist drill bits, a hand-turned device, without the additional mechanical power of a brace, can be controlled so it will not plunge by using a basic neurosurgical tactile technique. In other words, the safety taper of the tumi presumably offered significant benefit and was no doubt quite ingenious. Nevertheless, without power beyond the hand, wrist, or even the bow (and, perhaps, the fear of law suits), the need for such a safety device was probably not as crucial as it became after the mechanical advantage of this brace gained popularity.

The appearance of the cutting device attached to a dura-protecting button, in existence for so many years before its wide acceptance, seems less an example of absent need and more an example of absent power. One can only imagine the time, effort, and frustration experienced by Galen creating his cranial incisions in such a manner. Somewhat less frustrating, but still highly unsatisfactory, was the lack of rotational torque provided by the small electric motor, and even less by the hand crank, which Dr. Cryer proposed for his device (Fig. 7). His design was ingenious, but for lack of the availability of adequate torque power, it was a little before its time.

In their comprehensive review of the neurosurgical engine, Pait et al.9 described a number of craniotome-like devices that were available during the last few years of the 19th century and the first 2 decades of the 20th century. Most of them have completely vanished. Hartley and Kenyon,4 the developers of the compressed air–driven engine that some consider to be the best of these, saw the clear surgical benefit of the fast cut made by such a device. They favored a rotating drill very similar to the one that remains in use today. However, Hartley and Kenyon, themselves, complained that the cut made by that drill was too wide. It was not until the high torque of the currently available engines appeared that the drill design they favored became thin enough to guarantee its ultimate acceptance.

The Desire for an Axial View of the Spine

In 1975, an understanding of the role of the hypertrophied facet joint in lumbar radicular disease was rapidly gaining acceptance. A desire for an axial view of the bony anatomy was evident. In that year, the Journal of Neurosurgery published 2 back-to-back articles by Robert...
Genesis of neurosurgical technology

Jacobson et al.,5,6 in which the authors described a technique for radiographically visualizing the spine, along its axis, using polytomography, which had previously been used for fine resolution imaging of head and neck bony anatomy. In polytomography, an x-ray tube and an image-intensifier move in opposite directions, creating a central high resolution in-plane “section” superimposed by two large out-of-plane anatomical volumes of data. This technique, first described two years earlier by the same group, was called transverse axial tomography.

At the time, the images were thought to be too difficult to interpret, and 2 years later, whole-body axial CT scanning made the elegant invention of transverse axial tomography as obsolete as the audiocassette made the 8-track tape. To a generation of neurosurgeons used to looking at anatomy from an axial viewpoint, however, the images are not hard to interpret at all (Fig. 11).

Of note, the mathematical equation that made CT possible was devised by Radon in 1917.10 Radon’s equation remained theoretical until the invention of the computer, decades later. Ultimately, its use for tomography was made practical with minicomputers that were the computational tool for the EMI Mark-I, the first CT scanner for which Hounsfield received the Nobel Prize in medicine in 1979. In contrast, Dr. Jacobson’s brilliant marriage of preexisting technologies and applications to fulfill an unquestioned need, just 4 years earlier, has been all but forgotten.

Conclusions

In his book, Guns, Germs and Steel, Jared Diamond posits the thesis that technology is never simply the result of a brilliant idea that fulfills a clear need but rather the result of such an idea and such a need, existing in an environment that already offers everything required to support its growth and development.3 This is so, even if the potential benefit of that technology is clearly evident. Unless all of this is present, technological ideas, no matter how ingenious, will never gain popular acceptance. Neurosurgical technology is no exception to this.

Disclaimer

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References


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WILLIAM CARROLL BERGMAN, M.D., F.A.C.S.
1947–2009

It is with great sadness that I report the sudden passing of my friend and professional colleague Dr. Bill Bergman on August 8, 2009. Bill was born in Philadelphia, graduated Phi Beta Kappa, and attended medical school at the University of Pennsylvania. He interned at Bellevue in New York City and did his neurosurgical residency at the University of Miami under Hubert L. Rosomoff, M.D.

Initially stationed at Oak Knoll Naval Hospital in Oakland, Bill soon became Chief of Neurosurgery at Letterman Army Medical Center, during which time he participated in Desert Shield/Desert Storm and was instrumental in bringing the first CT scanner to the battlefront. After Letterman closed he was appointed consultant to the Surgeon General of the Army at Walter Reed Army Hospital in Washington, D.C., during which time he also served as Director of Neurosurgical Research. He
was also Commander of the 352nd Command Support Hospital, achieving the rank of Colonel.

Bill returned to the San Francisco Bay Area and ultimately became Chief of Neurosurgery at Santa Clara Valley Medical Center (SCVMC) in San Jose, California. His affiliation with UCSF, begun during the period at Letterman, continued throughout his career. He retired from SCVMC to serve the community at Mills-Peninsula in San Mateo and in Redding and to continue his passion for teaching at San Francisco General Hospital.

His love of neurosurgical research was evident in his 80 presentations and publications at neurosurgical and other medical meetings during our 16-year affiliation. He had a particular passion for the history of neurosurgery and had 34 historical presentations at the meetings of the College of Neurological Surgeons/American Association of Neurological Surgeons.

Bill was very caring and he had a great sense of humor. He was a consummate patient’s physician. That Bill unselfishly gave of himself was deeply felt by his peers, colleagues, and all those he touched. Bill will be greatly missed by the family members, friends, patients, and medical colleagues who came to cherish his upbeat spirit and to whom he devoted his life.

Bill is survived by his mother, Alyce Bergman, in Philadelphia, his wife, Shelley, and daughter, Marchesa, in San Francisco. This paper, which he coauthored, is dedicated to his memory.

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