
MEDICAL HISTORY

A BRIEF HISTORY OF EXPERIMENTATION ON CONDEMNED AND EXECUTED HUMANS

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Experimentation on condemned men is assumed to have been a common practice in ancient Alexandria, but disappeared in Rome and during the Middle Ages. Sporadic cases were documented in the Renaissance and afterward, involving experiments both before and immediately after execution. The advent of the guillotine raised the question of possible persistence of consciousness after execution and that spurred much electrophysiological study of freshly decapitated heads and bodies. In 19th-century Europe, interest focused on cardiac function immediately after beheading. In the early 20th century, many condemned men in the Philippines were used

by American physicians for their research on plague and beriberi.

Briefly discussed is the relevance of the practice of human sacrifice in Homeric Greece and Mayan Yucatan, as well as experiments on black slaves in America. The Nazi medical crimes of World War II encompass a totally different morality, and are not really comparable to the matter at hand. They have, however, so stirred emotions as to discredit the general concept of experimentation associated with capital punishment. Even within the framework of our system of jurisprudence, the altruistic desires of many now languishing on death row are being ignored.

Among the ethical problems magnified for an already uncertain society by current sociopolitical and technological shocks is the lack of definition of acceptable limits for experimentation on human beings. The ethics and practice of research on ill and healthy adults and children (with and without their consent), on criminals and political prisoners,^{1,2} and on oneself,³ have been well documented and analyzed. Comparable in-depth treatment is not available for those unique episodes involving persons condemned to death through an edict. The usual scrutiny extends no further than the sensational Nazi medical atrocities of World War II,^{4,6} which seem to have irreparably tainted all such endeavors.

Sometimes derisively referred to as human vivisection, similar experiments indeed have been carried out within the proper framework of civil law during peacetime, when radically different ethical principles necessarily apply. In part, the ostensible neglect may be due to the fact that reports of such experiments are rare, usually terse, and found only in obscure publications. Discussion of their extraordinary ethical implications is disjointed and inadequate at best. This topic still seems to be of little interest or importance in today's scientific community, perhaps because it is accorded the emotionally charged repugnance of the death penalty. This brief chronicle of pertinent historical facts and ideas is aimed at ameliorating such judgments.

A HISTORICAL REVIEW OF HUMAN EXPERIMENTATION

In the Ancient World

The story begins almost 3,000 years ago and is fraught with controversy. No definite records have survived to verify direct evidence of experiments on the condemned in Homeric Greece.⁷ Those who find such experimentations plausible

point to the quality of medical knowledge attributed to physicians in Homer's works. This suggests to them that its only possible basis was the direct observation afforded by dissection of the human body.^{7,8} Some of the latter might have been alive and selected to serve as "food" for the gods in ritual human sacrifices, a common practice during that period.⁹ On the other hand, those who deny the possibility of dissections based on this literary evidence say that medical knowledge could have been gained simply from observation and treatment of battle wounds.⁷⁻⁸ They further insist that the combination of a universal dread of cadavers and of the strong religious and magical taboos in the ancient mind made even postmortem human dissection unthinkable.⁷

The case for experimentation on the live condemned to death in Hellenistic Alexandria (ca 300-200 BC) is more compelling, despite the fact that here, too, direct contemporaneous proof is lacking. It is likely that dissection and vivisection of human bodies began and developed simultaneously in that first golden age of anatomy.⁷ The pioneering Alexandrians probably were influenced by contact with ancient Egypt; its tradition of embalming provided excellent opportunities to explore the structure and relationships of internal body parts.¹⁰ Alexandria's enlightened atmosphere was due primarily to the intense scientific interest of the Ptolemies, some of whom participated in routine anatomical dissections.¹¹ This encouraged the then dominant group, known as Dogmatists, to evaluate the dynamism of physiology over that of static anatomy. The two famous giants of the time were Herophilus, the father of anatomy, and his younger colleague Erasistratus, the father of physiology.¹² Both are said to have performed human vivisection on a scale unmatched in human history.^{7,11}

The Ptolemies were of the opinion that there was a need for objective knowledge and they decreed that condemned criminals should submit themselves to experimentation because they owed society a great debt.¹³ Earliest extant reports from Roman historians four centuries later accuse the two Alexandrian scientists, Herophilus and Erasistratus, of having performed up to 600 human vivisections. This data was passed on to ancient Rome, but much of it is now lost.^{13,14} Details about the sex and age of the subjects, the form of anes-

thesia used (if any), and the information obtained, which would lend more credence to the indirect, ie, literature, reports, are not available.

It is generally agreed that human vivisection was indeed practiced on a grand scale during the hegemony of the Dogmatic school. It is hardly conceivable that Celsus and Tertullian invented the fiction merely to make their treatises more entertaining.¹¹ Both historians repudiated the practice of opening live bodies to observe nature at work. Tertullian went so far as to call the two Alexandrian scientists fanatical butchers.¹⁴ Celsus' criticism was milder; he deemed it better to get the facts from corpses, or from examination of wounds,¹³ in a manner later raised to an art by Galen called "vulneraria speculatio," the contemplation of wounds.¹⁵

The unique aspects of the Dogmatists' philosophy created an ideal milieu for vivisection. Their penchant for the study of function required research on living persons, not out of cruel curiosity, but rather as the indispensable means in the serious pursuit of biological truth. For them, the potential suffering of a few social debtors could bequeath great benefit to future generations.⁶ In addition, Dogmatists questioned the wisdom of applying results from animal studies to man.¹⁶ At this time, the condemned were ranked with animals in the social order, and Alexandrian citizens were also losing their status through gradual disenfranchisement. The inevitable outcome was contempt for the mortal body and exaltation of the soul that doomed criminals were supposed to have forfeited.¹⁶

Dissenting historians doubt the probability of the sanctioned scientific slaughter of 600 condemned criminals.¹⁰ It was never mentioned by Galen who often opposed the views of Erasistratus.¹⁷ Galen's outlook might have been conditioned by the Empiricists who represented only one of the many sects that rose to prominence during the decline of Alexandria and the Dogmatic school. As in ancient Greece, these succeeding Alexandrian sects relied more on philosophical theorizing than on objective inquiry and, therefore, rejected vivisection as being cruel and useless.¹⁸ Celsus agreed with their contention that the practice defeats its own purpose because immediately after the body is opened, the color, texture, and other qualities of body parts differ from those

in an untouched state.¹⁹ Consequently, all traces of human vivisection in Alexandria vanished along with the Dogmatists.

Shortly thereafter the scene shifted to Pergamum where the ruling king, Attalus Philométor (a contemporary of Cato) was preoccupied with the nurture and study of poisonous plants. Such a passion was denigrated by other warring monarchs as unworthy of a strong leader; nonetheless, in 137 BC the king tested various poisonous plants and antidotes on condemned criminals. No further details are given in published accounts.^{20,21}

The Renaissance

All human dissection was discouraged during the Middle Ages, but the Renaissance fostered the reappearance of vivisection.²² A thief, referred to as the Archer of Meudon, was condemned to die on the gallows of Montfaulcon in Paris (January 1474), partly because he committed the sacrilege of stealing from the church. Many villagers, including high officials and the Archer, himself, suffered symptoms attributed to renal calculi. Local surgeons decided to resort to nephrotomy, which had been previously abandoned in Europe, but was still a part of Arabian medicine. Following rejection of his judicial appeal, the condemned thief was placed at the disposal of surgeons by King Louis XI. The operation took place during a remission of symptoms. An accidental incision opened the peritoneal cavity and exposed loops of bowel that were replaced. There was no mention of calculi having been observed, or removed. The archer survived the ordeal; and, coincidentally, there was a remarkable diminution of renal calculi symptoms throughout the region.

A few unsubstantiated accusations of vivisection cropped up in the next century. Having been falsely accused of vivisectioning humans, Berengarius in 1521 vindicated himself by explaining that his "anatomia vivis" incorporated knowledge gained through routine surgery, "anatomia fortuita," and through "vulneraria speculatio." During either the surgery or the observation, the

anguished cries of patients undoubtedly had been misinterpreted by horrified and superstitious laymen.²³ About the same time (1563), Vesalius' pilgrimage to Jerusalem was rumored to have been a penitential act for performing an accidental vivisection.²⁴ Perhaps the rumour arose from Vesalius' prior reputation for dissecting bodies of executed criminals.

Although controversy continues to surround Vesalius' pupil, Fallopius, the latter's own book yields incontrovertible proof.²⁵ In 1563, the Grand Duke of Tuscany gave the Pisan professor of anatomy custody of a condemned criminal to do with as he wished. The condemned was suffering from quartan fever. Fallopius wanted to test the therapeutic efficacy of opium, but an initial dose of three drams during a paroxysm had no effect. The criminal was willing to undergo another trial with the hope of winning a pardon from the duke. The second dose of three drams was given during a remission; this time the result was death. The experiment was criticized two centuries later as having been comparable to what were then considered the atrocities of Alexandria. Critics deemed it incredible that a Christian physician could be so "barbaric" in so "enlightened" a time.²⁶ Another account dismisses the entire affair as being a figment of extreme overreaction to Fallopius' well-known zeal for research,²⁴ but the old professor's own words prove otherwise.

Mayan Civilization

The widespread and gruesome practice of religious human sacrifice among the Mayans of the Yucatan is tangentially relevant. According to an eyewitness account from the 16th century,²⁷ on certain festive days, as well as in times of misfortune and necessity, the high priests ordered human sacrifices.

Victims included captured slaves, ordinary citizens convicted of various crimes, and even innocent sons and nephews. Thus condemned to death for purely religious reasons, each victim was held by his arms and legs over a large stone as the

executioner quickly and skillfully cut into the left side of the chest with a stone knife. The priest then thrust in his hand and tore out the beating heart, which he placed on a plate. Sometimes, fresh blood from the heart was used to anoint idols before the organ was cremated. The dead body, always considered holy, was flensed (except for hands and feet). The skin was draped over the naked body of a priest who then joined others in a solemn dance. The peeled body was eaten with religious reverence; the hands, feet, and head were reserved for priests. On occasion, the body was buried in a temple courtyard. Bones of sacrificed slaves were especially coveted by their masters as trophies of victory in ceremonial dances.

Although it seems reasonable to assume that important biological facts were gleaned, either incidentally or purposely, from the many thousands of human sacrifices in the relatively advanced Mayan society, there is no documented justification for doing so.

In contrast to the deeply religious significance of Mayan cannibalism, the South American Indians were totally worldly. They usually fattened their victims for nutritive enhancement, or for commercial sale.

The Enlightenment

The next verified episode of scientific experimentation on the condemned was almost two centuries after Fallopius' abortive attempt. In 18th-century England, Princess Caroline of Wales (later queen as the wife of George IV) ordered her physician to test smallpox vaccine on six condemned men before administering it to her children.²⁸

Despite the generally unfavorable attitude toward such experimentation prevalent in society at the time, in 1743 it was proposed that a condemned man in London be subjected to an experiment aimed at clarifying whether or not there existed some sort of canal between the oral cavity and the ear. The proposal was vehemently rejected.²⁹

There was a gradual change of public sentiment

in the late 18th century,^{3,30} coinciding with important discoveries in electricity that began to influence physiological research. Galvani's concept of "animal electricity"³¹ raised hopes that science was on the verge of uncovering the ultimate essence of life itself. His work prompted feverish research in support of various conflicting theories, all of which necessarily centered around the moment of death. After much research on sacrificed animals, investigators inevitably took advantage of society's increasing lenity and turned to the extraordinary opportunities offered by judicial executions. Most of the experiments planned for the condemned criminals were designed to make use of visual observations in lieu of objective measurements made by extant devices.³² At first glance, the aims and methods might strike us as having been despicable forerunners of the concentration camp tragedies of our time. Even superficial comparison reveals significant vindicating differences. These 18th century investigators were highly respected, compassionate, and competent men dedicated solely to wresting what for them were quintessential secrets of life from the bodies of justly condemned criminals after execution.³²

One of the earliest experiments on criminals condemned to death took place in Germany in 1791. In the presence of physicians and students assembled at the site of an execution by decapitation, the investigator began by demonstrating that exposed parts of the torso's neck muscles quiver when touched with a probe. Deeper contact caused muscular contractions strong enough to arch the back and to abduct the arms that had been folded with fingers interdigitated. A light touch of the probe on the cut end of the spinal cord in the neck likewise evoked facial muscle twitches, especially around the lips, and occasional retraction of eyelids. Deeper probing again caused massive contraction of all facial and tongue muscles. Such grotesque grimaces forced some shuddering observers to leave. The results led to the conclusion that consciousness probably persisted after decapitation.³³

The same verdict was reached by another German investigator who used galvanic stimulation to elicit contractions in the severed heads of men and animals.³⁴ The deepening controversy over the possible persistence of consciousness spawned similar experimentation in other leading nations of

Europe. The famed Bichat (at the Hôtel-Dieu in Paris) was among the first to study the effects of galvanism on guillotined criminals,³⁵ in all likelihood with the intent of establishing more firmly his newly propounded doctrine of vitalism.

From Turin³⁶ came a report of galvanic stimulation performed in August 1802 by Italian physicians on the bodies of three decapitated criminals, again before a large audience. The first experiment was begun 20 minutes after execution. When one pole of the galvanic pile was connected with the torso's spinal cord and the other with the surface of the exposed heart, the latter contracted strongly and continued to do so even after the circuit was broken. (In a way, this experiment anticipated today's cardioversion maneuver.) When tested on the other bodies only five minutes after beheading, the contractions were appreciably more vigorous. Stimulation of the aorta and other large arteries filled with warm water also yielded strong contractions. Reactivity of the heart disappeared in about 40 minutes, but that of the voluntary muscle persisted longer. There is no mention of concern with the severed heads.

Authorities in England permitted an Italian visitor to demonstrate the utility of his earlier research in Bologna on the body of a 26-year-old Englishman put to death in January 1803.³⁷ The method of execution is not specified, but it can be inferred that the man was either hanged or garroted. The body remained outdoors for one hour at a temperature of 2° F before being taken to a nearby laboratory equipped with a galvanic pile consisting of three troughs connected together, each with 40 paired plates of copper and zinc. Contact electrodes were moistened with salt solution. When one was placed on an ear, and the other on either lip, the jaws quivered and, at least, one eye opened; when on both ears, all muscles contracted, the slightly protruding tongue pulled back, and the entire head moved. The latter response was even stronger on ear-nostril contacts. The response to the ear-rectum circuit was so strong that it gave some of the onlookers the impression the body was reviving.

Identical results were obtained when only one trough was used. No reaction was noted on contact with exposed surfaces of gluteal and gastrocnemius muscles, or the heart. This lack of reaction was judged by later critics to have been due to

low temperature, and too long a time interval after death. Nevertheless, the investigator was convinced that he had proved the efficacy of galvanic stimulation as a powerful means to combat asphyxia and suspended animation.

The same Italian investigator performed previous work on beheaded criminals in Bologna.³⁸ There he had noted that when galvanic contact was made to upper and lower lips, a small amount of saliva flowed from the mouth; disparate strength of facial muscular contractions presented a picture reminiscent of unilateral paralysis. Grotesque grimacing resulted when contact was made to an ear on each of two severed heads, lying on their sides on a table with their necks touching. The reactions were much stronger than in either head alone. This led to the rationalization that "animal moisture" must somehow make up for the deficit in continuity of nerve and muscle fibers.

The brain of one head was then exposed; galvanic contact on its surface again produced contractions of all facial muscles. An ear-corpus callosum circuit led to additional violent shaking of the head. Direct contact with optic and olfactory nerves gave no reaction. During exposure of the brain, the investigator noted contraction of facial musculature with each cut of the scalpel in the soft tissues of the forehead. This is not seen during routine autopsies on fresh bodies; thus, he felt it could have been due to conditioning by prior galvanic induction. Because the aim of these studies was concerned only with the problem of consciousness, the results of further experimentation on the headless torsos were not reported.

The expanding controversy over the possible persistence of consciousness in severed heads was fueled not only by proliferation of this kind of research, but also by the prevailing custom of reporting detailed results in ordinary newspapers.³² On one hand, it was alleged that spontaneous muscular twitches and contractions in a freshly severed head devoid of blood manifested the possibility of conscious perception of pain, lasting perhaps for a quarter of an hour.³⁹

Contrary opinion rested on the assumption that there was a direction of flow of an hypothesized life essence called "nerve ether," or "nerve fluid," which filled the cerebral ventricles.³² This fluid was said to be derived from blood and was considered to be identical to electricity, to "ani-

mal spirit," to phlogiston, to "fine half-gas," or some other peculiar vapor. It was postulated that sensibility, or consciousness, was engendered by centripetal flow of the "fluid" along nerves to the brain and excitability, or contractility, by centrifugal flow. Consequently, almost instantaneous loss of blood upon beheading totally stopped the supply of "fluid" to the brain and, thereby, eliminated any possibility of consciousness, whereas, remnants already en route peripherally along nerves accounted for latent, or elicited, reactivity.⁴⁰

Repeated experiments merely polarized the conflict. Proponents of consciousness cited recent observations made on the head of an executed criminal. The criminal died by sword on the morning of February 25, 1803, in Breslau.⁴¹ A galvanic device composed of zinc and silver plates was used to evoke the previously described, strong muscular contractions in the head. The investigator then had two assistants hold the head firmly in their hands while he stared intently at the face. When the cut end of the cord was now touched with a mechanical probe, the lips contorted and the facial muscles reacted in a way which impressed the observer as a sure sign of sensed pain. When a finger was quickly thrust toward the open eye of the severed head, the lids closed as though the brain were conscious of an immediate threat. The same response was elicited by holding the head high with the face directed toward the sun.

Each time the victim's name was shouted into an ear, the head's eyelids opened, the gaze turned slowly to that side, and the mouth made opening movements as if trying to speak. These reactions ostensibly confirmed the hypothesis made by the proponents of consciousness. The investigator forgot to test for residual olfaction, due to the anxiety of hurrying the experiment and the pressing interest of numerous onlookers. With a watch in hand, a local merchant announced that one and a half minutes had elapsed at the end of the hearing tests. Muscular response to repetition of the initial galvanic stimulation was now weaker, but deep mechanical probing of the spinal cord yielded facial contortions violent enough to cause many to shout, "He's alive!" Eyelids slammed shut, and were further compressed by cheeks puffed with muscular contractions as though in pain. Teeth clamped down on fingers inserted into the mouth, even more forcefully with repeated probing of the

cord. Another independent experiment of this kind revealed traces of reactivity for more than an hour after decapitation.⁴²

Many of these observations are contradicted by a detailed account of experiments performed several months later in Mainz on seven of 20 criminals guillotined on November 21, 1803. A special two-room hut had been built on the site. One room was equipped only for galvanic studies. The other had an oven for temperature control, and contained voltaic columns and Leyden jars for electrical stimulation. It was hoped that this experiment would elucidate the fundamental relationship between galvanism and electricity. The research team consisted of nine outstanding physicians, surgeons, and pharmacists, and three medical students.⁴³

Two of the students were stationed directly beneath the scaffold. It was their task to check for any evidence of consciousness immediately after decapitation. One student held the head firmly in both hands for concentrated observation of the face, while the other shouted "Do you hear me?" in the ears. Alternating tasks, they did this with seven heads whose stationary eyelids varied from total retraction to total occlusion. In no instance was any kind of reaction observed. This team concluded that loss of consciousness is practically instantaneous and irrevocable upon decapitation.

The first headless torso was delivered to the galvanic room in four minutes. Stimulation of the exposed end of the spinal cord with leads from a galvanic pile of zinc and copper plates yielded the now well-known contractions of voluntary muscle, as well as gurgling sounds due to expulsion of air from the lungs. It was proved that smooth muscle reaction is weaker by inserting the copper lead (wrapped in a sponge soaked in a solution of ammonium chloride) high into the colon. The second body arrived in the galvanic room 22 minutes after beheading.

Four other bodies were quickly brought to the second room where 11 experiments were performed with direct electrical stimulation. It was determined that the application of electrical charges had no appreciable affect on the inability of blood and lymphatic vessels to absorb a resinous solution injected into the body's serosal cavities. Dissection of eyes after electrical experiments, in some instances, revealed liquefaction of

cataractous lenses. This raised hopes that electrical stimulation might constitute an entirely new form of therapy. The finding could not be confirmed by others, and became the topic of a bitter dispute aired in the newspapers.³²

Finally, at a time when fear of premature burial was rampant, one result was declared to be of great practical value. Electrical stimulation of a short segment of exposed peripheral nerve could serve as a certain indicator of death. This would eliminate the need to await the onset of putrefaction in costly, and otherwise objectionable, storehouses for cadavers.⁴⁴

Inextricably tied to the debate over consciousness was another concern, the relative merits of decapitation vs hanging. As mentioned, proponents of the latter insisted that spontaneous muscular activity after beheading and complete exsanguination signified the possibility of residual consciousness, especially when the brain is untouched.^{33,34} Citing earlier observations, they were convinced that the severed head would even speak if the larynx were not destroyed, and if air could somehow be directed through it.³⁹ These critics considered beheading to be especially cruel because the blade strikes at the body's most sensitive point "where all nerves run together and are united."³³

In the final analysis, they argued, any kind of muscular activity is of no decisive consequence. Functional integrity of the nervous system (which can be manifested by, but is independent of overt action) could be perhaps maintained after massive exsanguination by small amounts of slowly flowing blood still trapped in the finer vascular network.⁴⁵ Furthermore, just as the temporary numbness, sometimes associated with the sudden onset of very severe pain, can be dispelled by a subsequent powerful stimulus, so too could the evanescent extinction of neurocerebral excitability (induced by the decapitating blade) be reversed by the jarring stimulus of the head hitting the basket, or the ground, or by galvanic, or electrical jolts. Any of these might be the trigger for the reestablishment of perception.

In contrast, if the hanging noose is correctly applied, the sudden complete damming of blood in the head causes rapid onset of irreversible unconsciousness due to cerebral swelling and rupture of small vessels. An argument considered to be

unanswerable in this regard was the testimony of persons rescued from hanging. According to their testimony, loss of consciousness ensued without pain, or any other discomfort, except for occasional flashes of light, or bell-like sounds. Comparable verification from victims of beheading is, of course, out of the question.⁴⁵

That the dilemma is insoluble was acknowledged by the king of Prussia in a letter to the chancellor in April 1803. In his royal opinion, the experiments on beheaded men merely proved the existence of muscular contractility, but the imputation of consciousness was untenable. Only incontrovertible evidence would compel him to change the method of execution.⁴⁵

These experiments on guillotined criminals may seem to have been unduly macabre but, in reality, they were consonant with contemporaneous ethical principles.³² The status of the condemned coincided with that of capital offenders in ancient Alexandria. During both historical epochs, such criminals were considered to be more valuable than any animal as an object for research and, thus, could make recompense to society. It was deemed far better for authorities to permit beneficial use of the bodies than to comply with the medieval custom of leaving them to the ravages of exposure and predatory animals. In a similar manner to their Dogmatist predecessors, 18th century investigators decided that human subjects were indispensable in certain realms of inquiry (eg, human consciousness) if errors, such as those fostered by Galen's animal studies, were to be avoided.³²

The apparent repugnance of the burgeoning practice, nevertheless, led to the imposition of some restraints. In an earlier missive in 1803, the Prussian king demanded that local authorities impose strict rules upon physicians' applications for permission to experiment on guillotined men. The authorities were advised to be more cognizant of the aims, implications, and repulsive nature of such research.⁴⁵

Tighter control did not mean total abolition. In fact, a few years later, it was permissible to experiment on condemned men even before execution.^{3,30} This usually entailed obtaining the criminal's consent. Many criminals were eager to submit in the hope of being rewarded with the commutation of their sentences, or outright

parole. The practice of granting such favors was not universally endorsed. Claude Bernard was among those who decried pardoning survivors of research. Although he opposed the use of condemned criminals in scientific experiments, he, nevertheless, approved of the removal and use of their tissues and organs after decapitation.³⁰

The next instance of experimentation performed before execution was in France in 1834. Previously injecting himself with material from a plague victim in order to describe the illness in detail, a physician requested that he be allowed to extend his research on live condemned men. Permission was granted; five prisoners volunteered. Details of the experiments are not given. Only one of the subjects died before execution; it is not certain that the research itself was the specific cause.³

Again in France, a woman condemned to death in 1855 was the involuntary subject of helminthological research.⁴⁶ Cysticerci were taken from a pig and (in groups of 12, 18, 15, 12, and 18) were fed to the woman, without her knowledge, in sausage and soup (72, 60, 36, 24, and 12 hours, respectively) before her execution. An autopsy was performed two days after her death; it revealed that there were four young tapeworms in the duodenal lumen, the scolex of only one having a complete set of hooklets. Six other worms outside the lumen lacked hooklets. Although the investigator claimed that the results were conclusive, others doubted that the observed worms stemmed from the ingested larvae. The first group of larvae were fed to her 64 hours after having been acquired from the pig. This may have been too long a time outside the host's body for the larvae to remain viable.

At the same time, other physicians in Europe took advantage of executions in order to study cardiac physiology. According to a report from Germany in 1852, the heart of a criminal showed completely spontaneous and rhythmic right atrial and concomitant, but weaker, right ventricular contractions 15 minutes after execution by guillotine. The left side was motionless. Repeated electrical stimulation of the heart *in situ* stopped the contractions intermittently, but activity always recurred. The cardiac action unexpectedly strengthened 35 minutes after decapitation. Observers attributed this action to the effect of the reflux of

blood into the heart from manipulation of abdominal organs during autopsy.⁴⁷

Similar observations were made a few years later in France. Contractions persisted in all chambers of the heart in the body of a 38-year-old man guillotined in 1887, continued for 25 minutes after decapitation in the ventricles, and for 65 minutes in the atria.⁴⁸ The heart of another criminal executed in Paris in 1892 showed no activity in situ 45 minutes after beheading; mechanical and electrical stimulation were fruitless.⁴⁹ The researchers then tried, for the first time on a human heart, the resuscitative maneuvers perfected 11 years earlier on animal hearts, involving the perfusion of nutritive fluids into the coronary circulation.⁵⁰ The supply of defibrinated canine arterial blood to the coronary vessels of the human heart, via cannulation of the aortic arch one hour after decapitation, evoked weak contractions. Beginning at the apex of the right side, atrial rate was measured at 148/minute, ventricular 44/minute, which was strong enough to drive blood into the pulmonary circulation. The left side remained still. Contractions ended with fibrillation 23 minutes later; repetition of infusion of fresh dog's blood triggered coordinated contractions in all parts of the heart.

The 19th Century in America

Examples from the 19th century would not be complete without reference to experiments involving black slaves in the United States.⁵¹ It was an easy matter to subject slaves to experimentation at will in which the potential for crippling injury, or death, was entirely irrelevant. Fortunately, most procedures involved little danger, or cruelty. There is little evidence of outright malice on the part of the experimenters. Some of the latter used these opportunities merely to gain fame. Most were sincerely interested in testing new approaches to therapy, in gaining more knowledge, and in enhancing the quality of care. Many experiments dealt with treatments for smallpox and typhoid fever. A few were dramatic. The most brutal involved a male slave kept in an open-pit

oven to research a new method for treating heat stroke. The most useful, aimed at developing a good surgical technique for the repair of vesicovaginal fistulas, was carried out on a slave woman in Alabama.

Near the turn of the present century, a French physician used an ophthalmoscope to study retinas of criminals immediately after decapitation.⁵² Since its invention approximately a half-century earlier, the device was used on corpses by various investigators to describe findings that were said to constitute a relatively infallible sign of death.⁵³ The criminals' eyes revealed very thin retinal arteries, and the "box-car" beading of blood columns in the veins confirmed prior observations. Two other French physicians performed detailed retinoscopy on the eyes of guillotined men in 1929. They suggested that the beading of venous blood might signify either the instantaneous release of blood gases at the moment of death, or the much less likely possibility of intravascular gas due to immediate onset of putrefaction.⁵⁴

The 20th Century

Cardiac physiology was once again the subject of investigation in a detailed and well-controlled experiment on an isolated heart removed from the small body of a French woman executed by guillotine in February 1905. In situ observations confirmed those made in 1852. Perfusion of warm Ringer's solution into the isolated heart 13 minutes after decapitation strengthened the persistent weak contractions on the right side, and extended the contractions to the previously motionless left side. Contractility improved even more when warm defibrinated human blood replaced the Ringer's solution. All findings confirmed those resulting from prior animal studies; namely, increased pressure raised the rate and force of contraction, increased temperature of perfused blood raised the rate only, application of external heat or cold had no effect, and the influence of digitoxin was identical to that already noted in animals.⁵⁵

Americans became involved in research on condemned men early in the 20th century. The

first project was one dealing with the development of a plague vaccine. In 1905, an American physician stationed in the Philippine Islands (later, professor of tropical medicine at Harvard University) persuaded the governor to place 42 condemned convicts at his disposal. The convicts were injected subcutaneously with increasingly concentrated doses of cultured and attenuated plague organisms originally obtained from Europe. Prior testing had been done on guinea pigs and monkeys. The final injection to each recipient consisted of the product of an entire agar slant. No "accidents," or untoward sequelae, followed during a two-month observation period. An official report of the findings was read before the Manila Medical Society on November 6, 1905, and was published a year later. There was no mention of the matter of consent.⁵⁶ Interestingly, this episode is one of nine referred to by German physicians in their own defense at the Nuremberg Trials in 1947.⁵⁷

The same American physician collaborated on a second project dealing with beriberi. Again, the site is the Philippines in 1912. Twenty-nine condemned men took part after having given their informed consent; they were rewarded with unlimited quantities of cigars and cigarettes. Divided into four groups, the men were fed specifically varied diets for up to 115 days. An occasional death resulted from beriberi and from heart failure, confirmed by gross and microscopic autopsy findings. These experiments demonstrated conclusively that polished rice lacks an essential nutritional factor.⁵⁸

In Ceylon in November 1923, six condemned criminals were made quite ill through participation in experiments involving ingestion of carbon tetrachloride and strong purges of epsom salts. The undertaking, details of which were not specified, was denounced in the English press.⁵⁹

A rare and comparatively innocuous episode occurred quite recently in the United States. In Utah in 1938, a condemned murderer, after having chosen death by firing squad, permitted a physician to record the first (and apparently only) routine three-lead electrocardiographic response of a human heart being shattered by bullets. The tracing revealed the inconsequential fact that electrical death occurred in only 15.4 seconds following two brief spasms.⁶⁰

Unfortunately, the most recent, extensive, and

well-known experiments were those of the Nazi medical crimes of World War II. In a broader sense, those experiments do not rightfully pertain to the topic at hand because wartime atrocities are beyond the control of international law. Furthermore, the victims were condemned under "laws" spawned by a racial and political bias. Hitler's myth of a superior national common good set the stage for that shameful desecration of the Hippocratic legacy by demeaning the value of every individual and of all other nationalities.^{4,6,61}

The Nazi experiments had three areas of interest: (1) Primarily military, eg, the effects of freezing on personnel in high-altitude flights and in parachute jumps; (2) both military and general medical, eg, infectious diseases, fractures, and limb transplants; and (3) to satisfy the personal whims of SS officers, eg, the refinement of means for killing masses of people ("ktenology"), mass sterilization, and to supply material for bizarre collections of body parts, such as skin and skulls.

In no instance was consent asked for or implied, or anesthesia guaranteed. Some especially terrible experiments dealing with attempts either to prolong or to accelerate pregnancy led physicians to test the effects of various chemicals on the fetuses of previously injected pregnant women inmates. After birth, the babies were immediately vivisectioned and ultimately cremated.⁵ Although most of these experiments were scientifically unsound, some useful information did result from those dealing with malaria, with other infectious diseases, and with the handling of bone fractures.^{6,61}

The experimenters, many of whom were professors and members of the SS Medical Corps, had been selected more for their fanatical loyalty to the party and its cause than for their scientific talents. They formed the efficient instrument of a sort of "biocracy" committed to a self-styled biologic mission. They guided human evolution toward a "higher" transcendent principle that demanded the elimination of the captive human "vermin" in their camps. In experimenting on such "life unworthy of life," those physicians considered themselves to be the true "healers" of a debilitated human race.⁶² The Nuremberg Tribunal sentenced seven of the 23 defendants to death by hanging.⁶ The chief physician's suggestion, that his body be subjected to experimentation during the execution, was rejected by the court.⁶¹

CONCLUSIONS

Postwar analysis of Nazi experimentations on human beings seems to have been so excruciating that it blinded the civilized world to a very important point in the formulation of the Nuremberg Code. Nowhere in the code² is there any reference to experimentation (under anesthesia) on those who chose and desire it as an act of atonement when condemned to death by due process of peacetime jurisprudence. Those who oppose granting the condemned such a privilege fear that it would appear to endow the death penalty with undeserved beneficence and would vitiate their campaign for abolition of the penalty.⁶³ In reply to other critics who foresee no worthwhile results from a limited number of such experimental opportunities, one need only mention the stupendous impact made by the single awesome instance of cardiac catheterization performed by Forssmann (the winner of the Nobel Prize) on himself!

In recent years, proponents have argued cogently, and in vain, that such experimentation, within the stipulated constraints, is just and right.⁶⁴ The only circumstance in which a person may legitimately consent to a procedure implying certain death is as a necessary means to a very profound experimental end.⁶⁵ In the United States where death rows are once again becoming overpopulated, all condemned persons should be allowed to choose to submit to experimentation, or to organ donation, under strictly controlled anesthesia before ultimate death by lethal thiopental injection.^{66,67} All conflicting opinions aside, the decisive argument should be that of the condemned themselves. Many desire⁶⁸ such a chance for real and meaningful repayment to society, but their insignificant voices are lost in the din of society's ethical chaos.*

Because capital punishment has always been practiced somewhere and has been resumed in the United States, and because there always was and always will be a need for risky human experimentation, inevitably the two situations will converge with sufficient force to raise this now denigrated,

but honorable, concept to the dignity of an open, fair, and thorough assessment.

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*Author's personal communication with 33 condemned men now on death row in three states in 1984.

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