Techniques in Teaching

JOSEPH RANSOHOFF, M.D., M. VALLO BENJAMIN, M.D., AND ERWIN R. TICHAUER, M.D.
Departments of Neurosurgery and Division of Biomechanics, New York University Medical Center, and Center for Safety, New York University, New York, New York

It is indeed a challenging task that the steering committee of our workshop has asked us to undertake and we thank them for the honor they have extended to us. We have been forced to learn a great deal in preparation for this presentation and I hope we will succeed in transmitting some of this information to our fellow program directors so that it may serve to enrich the round table discussions which are to follow.

Certainly most of us in this room received our instruction in the skills of neurosurgery mainly through the preceptor relationship with our teachers, watching, assisting, trying ourselves, being corrected and trying again with greater awareness of the problem. While this man-to-man relationship will always be the backbone of our method of teaching the techniques of neurosurgery, we can only benefit by a closer analysis of the factors involved in this relationship and the potential areas for its reinforcement at critical points in our student's progress.

Decision-Making

As we apply our skills to fellow human beings, we cannot separate pure technique from decision-making; it is well known by students of motor learning that anxiety and undue tension severely interfere with motor performance. Placed is the surgical idiom we would say that one has great difficulty conducting a satisfactory operative procedure if one is not certain that the operation should have been carried out in the first place. It would seem worthwhile therefore to examine the decision-making process in neurosurgery as it relates to techniques and our ability to transmit this information to our trainees.

I have found it very helpful to utilize the concepts of systems analysis, or operational research and decision theory,\textsuperscript{4,5,8,9} in an examination of our decision-making procedures and technical choices. Systems analysis involves the distribution of the probability of success, weighing positive impact factors against negative impact factors for each move in a so-called "decision tree." In general, the relative importance of each move decreases as we progress out the decision tree, each branching being dependent upon the prior decision in an all or nothing, go or no go relationship. There are special positive and negative impact factors which must be considered at each branching or nodal point. Such an analysis of the critical moves necessary to achieve a goal can be utilized in considering the problems of erecting a skyscraper or conducting a neurosurgical procedure.

If we construct such a decision tree for a neurosurgical procedure, for example, the removal of an acoustic neurinoma (Fig. 1), the first decision to operate or not will be based on multiple factors such as age, general medical status, duration of symptoms, etc., all weighing in a positive or negative impact on the possibility of success. Having made the decision to operate, we move out the tree to the choice of anesthesia where the decision will be based on the same factors which were weighed in the decision to operate plus those additional factors pertaining particularly to this nodal point. Having made a choice of anesthesia we move on to the next nodal point and so on to the completion of the procedure. A complete awareness and understanding of the factors at each nodal point would reduce the number of decisions reached intuitively or "by the seat of our pants" and would improve our ability to pass this information along to our students.

While one can list quite simply the steps required to construct a building or perform a surgical procedure and construct a decision tree, this does not take into account the exi-
gencies which may arise during the conduct of the procedure which leads us to the concept of the "critical path," another aspect of systems analysis. The critical path implies that whereas the logical sequence of steps involved in the conduct of an operation can be listed from 1 to 30, the execution of these steps may require altering their order as they appear in our decision tree or at times even their complete omission in order to achieve our ultimate goal. For example, routine use of dural tenting suture prior to dural opening would be omitted by the experienced surgeon if faced with rapidly mounting intracranial pressure and returned to or omitted later in the procedure when the life threatening crisis had been passed.

So much for this digression into systems analysis as we might apply it to neurosurgical procedures. A better understanding of the paths chosen at each nodal point will, I believe, make us better teachers, reduce the anxiety and stress inherent in each decision for the learner and hence enhance the motor performance essential for a high level of technical skill. To quote from Cratty in his book, Movement, Behavior, and Motor Learning: "The effect of anxiety and stressful situations upon performance is a function of the task, of the general anxiety of the individual, of the prior practice in the task and a basic understanding of the goals involved. Stressful situations interfere with task performance of superior performers and within complex tasks."

**Evaluation of Motor Skills**

It can be safely assumed that most physicians embarking on a career in neurosurgery possess certain basic aptitudes as relate to motor performance which have attracted them to the field. Within the over-all group, however, it should be of considerable assistance in their training program to identify those who may need special assistance in perfecting their motor skills.

A considerable body of knowledge is available relative to man's use of tools and we can only briefly consider some aspects of the field. There are five basic hand grasps, the two primitive ones, the lateral and the contact grasp, the intermediate or power grip, and the two high skill grasps, the instrument grasp and the tripodal manipulative grasp (Fig. 2). Due to poor work habits or lack of experience there may be postural limitations which prevent the application of these aptitudes at a high level of skill. An initial evaluation consists therefore of an assessment of working posture with attention to such points, for example, as the wrist being slightly flexed for optimal manipulation, the elbow depressed for movements along the coronal plane and elevated along the sagittal plane, etc.

A number of motor aptitude tests are available which indicate the student's possible need for special training. Degree of awareness of sensory feedback can be evaluated by asking the trainee to push a coin against a positive stop instructing him to
cease pressure as soon as contact is made.\textsuperscript{12}

In an individual with a high degree of manual skill (Fig. 3) there is a sharp pressure spike, a plateau, and an immediate drop of pressure lasting about one-quarter of a second. In contrast, the individual who requires counseling will develop a much more gradual curve, reaching higher pressures and subsiding equally slowly.

The Purdue Peg Board Test will assess skills in positioning objects in space with and without visual control.\textsuperscript{1} Small cylinders or fluted pegs have to be inserted into flared and unflared orifices against a time limit. Without visual control we can evaluate kinesthetic ability and with visual control, eye-hand coordination.

The kinesthesiometer measures\textsuperscript{11} accel-

\begin{figure}[h]
    \centering
    \includegraphics[width=\textwidth]{fig2.png}
    \caption{Five basic grasps, illustrated in order of ascending difficulty (A through E). A. Wraparound grasp. B. Contact grasp. C. Power grip. D. Instrument or scoop grasp. E. Manipulative grasp. The highest levels of manipulative skill are shown in D and E; these should be acquired as early in childhood as possible for maximum efficiency (from Tichauer, Ergonomic Standards for Hand Tools, New York, Biomechanics Laboratory of the Center for Safety, 1969).}
\end{figure}
Fig. 3. Manual skill. One indicator of high manual skill is the ability to stop immediately on contact when an object is pushed against a positive stop. The solid line shows the pressure profile after contact produced by a highly skilled individual. The broken line is representative of an individual with good aptitude but poorly developed skill (from Tichauer, Ergonomic Standards for Hand Tools, New York, 1969).

eration and deceleration of the hand and records the aptitude for bringing an instrument down at a measured rate onto vulnerable tissue, in our case. These and other tests can be used to develop an inventory of aptitudes or so-called "static measures."

During training of motor skills, dynamic measurements of work are available which include the learner's curve, rating and the chronocyclegraphy. The learner's curve (Fig. 4) plots the number of practice cycles against the time required to perform a perfect maneuver. The curve for learning a simple task falls rapidly whereas that for more complex tasks plateaus to the "point of confidence." It is interesting to note that when the point of confidence has been reached, improvement will continue thereafter at the same rate with or without additional instruction.

Rating is a work study procedure which by means of mathematical formulae assesses the combination of manual dexterity, skill, consistence of performance and speed. Chronocyclegraphy assesses general motion patterns by means of infrared photography recording finger motions traced by small red spots used as reference points. It has been used with great success in training for fine operations such as the assembly of microcircuitry under the microscope or the inoculation of infectious viral material into eggs.

The opportunity to expose our trainees to this type of motor skill evaluation and provide them with counseling and training, which is readily available in departments of biomechanical engineering and biomechanics, is one which we should seriously consider. Our own resident staff has been most excited by our preliminary forays in this direction, realizing the possibilities of developing their motor skills, learning the basic rules of eye-hand coordination, two-handed motor tasks and the chance to develop work habits necessary for microsurgery and additional developments the future may bring.

Teaching of Surgical Anatomy

The secure conduct of a neurosurgical procedure is clearly based on a complete familiarity of the local anatomical relationship as reviewed at the time of the operation. Whereas gross and microscopic neuroanatomy is obviously the basis for this knowl-
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edge, structural relationships, as we all know, may look quite differently when seen through a craniotomy aperture as compared with the dissecting room views. Stereoscopic anatomic atlases are available as well as video teaching tapes but I do not believe these answer the specific need.

William Collins at Yale has utilized total simulation of the operating room situation in the autopsy suite to the point of providing the residents with an operating table, surgical type drapes and OR lighting in the conduct of mock operations. Under close to actual surgical conditions therefore, the proposed procedure is carried out and critical structures are marked with various colored clips. The brain is then removed in the routine autopsy fashion. Collins confirms what we all might expect: many times the cranial nerves, arterial branches or even cortical areas have been incorrectly identified.

Certainly this is an imaginative method for teaching surgical anatomy and encourages the resident to develop the special knowledge of spacial relationships necessary for the conduct of neurosurgical procedures. There are undoubtedly other methods for achieving these goals and it is assuredly an area which deserves our attention.

Animal Surgery

During the trainee's period in the research laboratory or in an animal operating suite, an obvious opportunity exists to perfect his surgical skills. This is especially pertinent when becoming familiar with newer techniques such as the operating microscope. However, the major thrust of research experience is not usually that of technical perfection, poor working habits can be developed during a period in the laboratory. While these may be acceptable for the basic researcher whose interest is primarily in the experiment at hand, they should not be permitted in our resident trainees.

It is important, therefore, to provide our residents with adequate instruments and personal supervision during the time he may spend in research endeavors if these involve the use of experimental animal preparations. He will thus obtain a positive impact relative to his surgical skills as well as achieving the primary goal of an awareness of scientific methodology and critical ability.

![Graph showing packing of penicillin bottles](image-url)

**Fig. 4.** Typical learner's curves. The curve for packing penicillin bottles requires little manual skill. The second one for assembling complex clockwork demands high levels of skill and intelligence. Notice the "point of confidence" at the end of a plateau, which indicates that the operation "has been learned."

Audiovisual Reinforcement

The ability to capture motor acts on color tape or film in order that they can be restudied innumerable times in a nonstressful environment seems to be an obvious method of reinforcement which should be available to the young resident. We are not now speaking of films on how to do an operation, clip an aneurysm, for example, but rather those prepared to illustrate the fundamentals of neurosurgical technique. As a demonstration for this presentation we have prepared such a short strip on techniques we employ for hemostasis in the brain, with the assistance of the Audiovisual Division of NYU. The tape divides the problem into three situations requiring special modifications of the basic methods of depending on the location of the vessel, i.e., surface, sulcal, or larger vessel within the depths of the brain. These techniques will obviously vary from program to program and thus the tapes are only of value to our residents who are being taught our techniques.

It is immediately obvious that this type of visual instruction lends itself to the addition
Fig. 5. Electromyogram of standard bayonet forceps indicating energy required and length of time to grasp, utilize, and release instrument.

of verbal or written instruction offering an explanation of the techniques employed, why and how they vary depending on the anatomical location and caliber of vessel being controlled and what the student should observe as he studies the tape.

There are many examples of this type of audiovisual aid which we can all enumerate, such as the techniques for developing standard bone flaps, for carrying out the various lobectomies, for exposure of the optic nerve, carotid artery complex, and so on. To be of greatest value, we re-emphasize that they should be individualized for each teaching program as they are designed to help your residents learn your methods. A library of such tapes would be our goal.

At a later date in the resident’s development, the opportunity to observe a re-play of his own performance should be of great value for both self-criticism and in discussion with his instructors. Here our interest would be in bimanual dexterity, simple motion studies and instrument handling.

Finally, in discussing teaching tapes and movies, we do not wish to de-emphasize the value of “how to do it” demonstrations made by those whom we all recognize as master technicians. These could be of great value for distribution to all training programs as they are not designed to teach, for example, how to get to the tentorial notch nearly as much as how the senior resident and independent operator should handle the aneurysm being filmed once he has arrived at that point.

It is of interest that the National Medical Audiovisual Center in Atlanta, Georgia, a subdivision of the National Library of Medicine, has a listing of some 60 films pertaining to neurosurgical procedures. There are certainly many others not registered with this agency and some attempt to add to their listing and thereby improve distribution might be a worthwhile endeavor.

Instrument Design
We would like now to focus our attention
on the matter of instrument design, an issue of obvious importance; our instruments serve as extensions of our minds and hands and are critical in techniques we employ. Surgical instruments have by and large been handed down from one generation to the next with little attention given to the assistance we might obtain from experts in the field of biomechanics and tool design. One has only to examine some of the beautifully finished microsurgical instruments currently available to realize that not only are the tips reduced in size to meet the needs of manipulation under magnification, but also the entire size of the instruments. How illogical; our hands are still the same size.

Let us examine the bayonet forceps inherited from our ENT colleagues and one of our most constantly employed instruments. It is difficult to pass and grasp quickly as it needs to roll between the thumb and opposing index and second fingers. When held and used for some time, one gets cramps in the muscles involved in thumb-finger opposition and when supplemented with electrocoagulating current through its handle's end, it becomes quite unbalanced. When passed by the unskilled or hurried scrub nurse it is as often upside down as not, even further increasing the time required to gain control.

Examination of this instrument was conducted by our biomechanical division by means of video tape supplemented by EMG analysis during actual usage; three components of instrument usage were analyzed, i.e.: grasp and control, hold and use, and release.* Their analysis suggested the need for a larger overall instrument (the exact dimensions still require study) with provisions for placement of the third, fourth, and fifth fingers, and an altered angle between handle and working tips. The accompanying figures (Figs. 5, 6, and 7) show a standard

*Mr. Mathew Miller, Assistant Research Scientist.
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bayonet forceps, an intermediate, and the prototype of a potentially improved forceps. EMG studies confirm a sharp decrease in time required to grasp and control as well as reduced energy during utilization and release.

This bayonet modification is presented as a crude example of what we hope will be the beginning of a scientific and cooperative analysis of the common surgical instruments used in our specialty. It seems clear that the better our tools, the better technicians we will become and the more rapidly will our students become proficient in their use.

Gilbreth, one of the founders of bio-engineering, took us to task in 1915 in a discussion of surgical instruments when he wrote: “Any classification of the tools used in surgery is pathetic and ridiculous. While great practice with comparatively few tools is one of the laws for the efficient use of tools, the constant incentive under present conditions in surgery is to design more tools. The laws and principles relating to efficiency of design, selection, and use of tools are well established. Increasing quality will not come by the practice of each surgeon designing new tools without the use of laboratory measurements and tests to compare new designs with existing standards.”

Summary

In an attempt to draw your attention to some aspects of the teaching of technique in neurosurgery, we have emphasized the fundamental importance of the teacher-pupil relationship. This basic phenomenon cannot be substituted for or replaced but probably can be beneficially supplemented by a number of activities. We have discussed ourselves as teachers and raised the question as to whether some attempts at formalization of our decision-making processes would enable us to understand and hence teach them with greater clarity.

Concerning our trainees, we have considered the possible advantages of a more formal evaluation of their motor skills and supplemental training when needed. We have examined the importance of surgical anatomy and methods of supplementing its instruction. The use of video tapes and films in

Fig. 7. Further modification. Note sharp reduction in grasp time, increased energy during usage, and reflection of increased tension in instrument.
technical instruction has been reviewed and suggested as an area for further investigation. Finally, we have considered the status of the design of our surgical instruments.

It is important to weigh the possible merit of the innovations we have discussed. Certainly change for its own sake is worthless and the most difficult issue we foresee is that of evaluating the effect of modified teaching methods on our trainees' ultimate skills as neurosurgeons.

References


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