The complexity of problems encountered with head trauma clients is vast and inconsistent. This article presents a conceptual model that provides structure, yet flexibility, in addressing any aspect of these problems. Emphasis is placed on the importance of sensorimotor integration as it pertains to normal movement or response patterns. Justification of treatment techniques is addressed by suggesting the use of a classification system to categorize methods of treatment according to the specific or multiple sensory modality facilitated when applying those techniques. The clinician's understanding of applied neuroanatomy and physiology serves as the substrate for developing a flexible rationale for use of sensory input to facilitate desired response patterns. The need for a problem-oriented approach is emphasized. The approach stressed understanding of the general clinical problems and their sequential nature, evaluation, goal setting, and treatment planning.

Key Words: Head injuries, Movement, Neurophysiology, Physical therapy.

Unlike the approaches for managing the neurological problems of clients with cerebral palsy, learning disabilities, or hemiplegia, no specific approaches to treatment of head-injured clients have been developed. For that reason, a problem-oriented approach based on integrating research findings, theory of CNS function and dysfunction, and treatment techniques for other neurological disabilities seems to be a logical choice for assessing and treating head-injured clients. A model that ties together the areas of sensorimotor development, neurophysiology, and learning into a clinical triad (Figure) should help the reader conceptualize the client's total needs and then approach the clinical problem in an orderly manner. The purpose of this article is to present a conceptual model that focuses on a global sensorimotor approach to treatment of head-trauma clients. The term normal sensorimotor integration means the total process from the introduction of all sensory input from the environment to the normally accepted behavioral responses of the client to that external world. The greater the flexibility of the client to adapt to changes in the external environment, the closer the rehabilitation team comes to reaching its ultimate goal—total rehabilitation. Emphasis is placed within the conceptual model on analysis of developmental sequencing, integration of treatment modalities, and variation in problems and recovery patterns of these clients. The model should provide a conceptual framework on which specific information about components of treatment can be integrated into a global approach applicable to clients with multiple and varied needs.

CONCEPTUAL MODEL

The conceptual model illustrated in the Figure represents three distinct areas of study: behavioral development or behavioral psychology, internal neuromechanisms incorporating applied neuroanatomy and neurophysiology, and internal and external learning environment. Each area could be considered a conceptual whole; yet when each is integrated with the others, a triad is created that gives additional meaning to the other two. The three divisions, when analyzed together, create a new conceptual whole.

Behavioral Development

Considering the complexity of a human being, identification of all aspects leading to a behavioral response becomes awesome. Yet, man's motor development does have consistencies. Certain behavioral patterns seem to be critical components of complex patterns that involve more advanced sensorimotor integration. All behavioral responses are based on sensory input and appropriate processing. For example, the postural holding patterns critical for head and shoulder girdle control in beginning prone activities are also critical for crawling, sitting, standing,
EVALUATION AND TREATMENT TRIAD

**Behavioral Development**
1. Identifies observable motor sequences leading to independence in higher level functional activities.
2. Gives constancy to commonalities of evaluation techniques.

**Internal and External Learning Environment**
1. Client and clinician dependent.
2. Based on individual differences before and after a traumatic injury to the CNS.

**Internal Neuromechanism**
1. Incorporates applied neuroanatomy and neurophysiology.
2. Gives structure to a classification schema based on current neurophysiological understanding of input, processing, and output.
3. Scientific basis for rationale used to explain treatment protocols.

*Figure. Evaluation and treatment triad: three components integrated into one problem-solving model.*

Walking, and many activities of daily living (ADL). The constancy of these observable patterns and their subsequent developmental sequences represent behavioral development, the first major component of the triad. The clinical application of behavioral development is based on the therapist's ability to observe the development of normal motor behavior, categorize it, subdivide it into its component parts, and sequence its maturation from simple to complex activities. Once variance in normal has been established, then observation of deviations from that norm can be analyzed. For example, assume a head-injured client stands with his left leg in hip extension, adduction, internal rotation; knee extension; ankle plantar flexion; and hindfoot inversion. The therapist, by knowing normal motor responses, can make an in-depth analysis of the standing pattern. In this case, certain components of the hip and knee responses are normal, but others deviate from a normal standing pattern. Changing the standing pattern to slight abduction and external rotation of the hip would be one goal. It is important for the therapist to know that the sequence of moving from half-kneeling to standing incorporates the response of hip extension, abduction, and external rotation; knee extension; ankle dorsiflexion; and hindfoot eversion. This information allows the clinician to try to facilitate a total motor response of the leg by using a developmental pattern that was first integrated earlier in the person's life, which would lead to the synergistic responses of normal standing. Knowledge of additional developmental patterns and combined responses to sensory input should help the clinician provide a variety of experiences for the client, all leading to the integrated activity of normal standing.

**Internal Neuromechanisms**

The specific rationale for why motor behaviors occur in sequential fashion and why motor responses can be changed by alterations in sensory input are based on current understanding of CNS functioning and development. Similarly, the reason why a certain input, such as stretch to a muscle, does not elicit the desired observable response of a muscle contraction can also be explained. These neuromechanisms represent the second component of the conceptual model. Scientific discovery constantly alters our knowledge base and helps refine our understanding of behavioral responses to input from the environment. This updating of current understanding has not negated the observed constancies of behavioral development and sensorimotor response patterns. On the contrary, it has enlarged our knowledge base on which we justify our treatment.

For example, a clinician might use a prolonged stretch technique to inhibit a spastic elbow flexor muscle and facilitate the antagonistic muscle or synergy. This technique might be performed while the client is in the side-lying position with the spastic upper extremity on the top side. Rolling the client toward the prone position to elicit protective extension of the spastic upper extremity could simultaneously be facilitated by eliciting various righting and
protective responses. The theoretical rationale for using the prolonged stretch of the spastic muscle might be that the impulses from the tendon organs of the stretched muscle would inhibit motor neurons controlling that muscle and would reciprocally facilitate those controlling the antagonistic muscle. Extension of the elbow would be further facilitated by eliciting the patterns of rolling and protective extension that lay the foundation for weight bearing and upper extremity independence. If tomorrow's research identified that the tendon organ and another sensory receptor, not yet identified, perform this function, then a clinician would still know an effective technique in altering tone and an additional reason to explain the behavior. Thus, the neurophysiological rationale would change slightly, but the behaviors remain constant. This change in rationale would illustrate the flexibility of the conceptual model, which permits alterations in one area while another component remains stable. In this case, the change would not negate using a body-righting response to facilitate rolling, which elicits elbow extension in a protective pattern.

Understanding the internal neuromechanisms of the CNS and their normal function helps clinicians analyze why a behavioral response is occurring in a client who has suffered a traumatic brain injury and leads to additional treatment alternatives. For example, if a client with a closed head injury exhibits a typical hemiplegic posturing of both upper extremities, then the neurotracts released from higher center control are probably the same as those released when a client develops a lesion in the internal capsule following occlusion of the middle cerebral artery. Thus, many of the treatment approaches used to facilitate normal movement in a unilateral hemiplegic client would be applicable to the person with a closed head injury.

Internal and External Learning Environment

Although the total neurophysiological sequences for sensorimotor integration remain constant, variability occurs in certain developmental characteristics. One child will scoot but another will crawl. Yet, both children need postural development of neck, trunk, and shoulder and hip girdles to carry out either movement pattern.7 The learning environment, based on genetic (internal) and environmental (external) factors, should account for this variance and is considered the third component of the clinical triad model. This component accounts for individual differences with respect to learning styles, preferential response patterns, psychosocial behavior, and many additional aspects of a client's personality that lead to variance in the processing of sensory stimuli and in ultimate behavioral response.8

All of these combined factors lead to the individuality of the client before injury. The sites and extent of the lesions after trauma, interacting with the preexisting state of the CNS, lead to large variance and individuality of functional abilities within the head-injured population. This concept in no way negates the understanding of behavior sequences leading to control and modification of responses nor the rationale behind implementing treatment modalities. The concept should underline the importance of understanding various ways humans learn and how to create a learning environment conducive to optimal learning for each client.

For example, assume you are treating a 21-year-old man who was majoring in architecture at a university and who never liked to read. His major interests were outdoor sports, and he sustained a closed head injury in a downhill skiing accident. From this information, a clinician who understands the principles of learning and brain processing should deduce that before the injury, this client probably had well-developed right parietal-occipital lobes and well-developed visual-spatial ability. His spatial ability might be better than his temporal sequencing.9,10 He would probably learn better from seeing or moving through an activity than by being told what to do. All of these preexisting factors, along with the lesion sites and their probable affect on sensorimotor functions, would need to be considered when creating the best treatment environment. Thus, preexisting preferential learning styles and existing lesions play a key role in establishing realistic goals, expectations, and alternative treatment sequences.

For another example, assume that before injury, a client had demonstrated poor verbal ability, good common sense judgment, good mathematical ability, and creative artistic skills. These were measured by his school achievement, aptitude tests, vocational choice, and family reports. He has just suffered a severe traumatic injury to the left hemisphere. Because this client had demonstrated high-level right hemispheric development and now has extreme left hemispheric damage, his potential for extensive spontaneous recovery or ease of relearning through preexisting nondamaged areas would seem much more than a client who suffered the same lesion but had not shown preexisting high-level development of the noninvolved hemisphere. Understanding hemispheric specialization10 and the factors that create an optimal learning environment should serve as a basis for developing guidelines to establish treatment goals and strategies throughout the entire recovery and rehabilitative process of the client.

Although the client has a preestablished internal system for sensing, transmitting, and processing sensory signals, the external environment determines the quantity and quality of the sensory stimuli. Thus, the
environment in which the client is placed has tremendous influence on internal processing of sensory stimuli. What a clinician might do during one hour of therapy (1/24th of a day) may be reinforced, be negated, or be in conflict with what is received by that client's CNS during the remainder of the day. A team approach emphasizing consistency within that daily environment would seem paramount.

Use of the Model

A clinical model, such as the one illustrated in the Figure, is only useful as a conceptual tool. It does not provide a step-by-step treatment procedure to be used in all situations. One key to successful use of a model is keeping all aspects of the model in mind when focusing on one component. For example, if a goal for a client is to gain independence in coming to sitting from supine, the clinician needs to know that humans normally come to sitting in one of three ways. This understanding gives flexibility to the clinician with respect to treatment sequences. Those three methods can be looked on in isolation or in combination to form new patterns, and they are presented below. The first pattern would be described as rolling to prone, pushing to four-point kneeling, rotating to a side-sitting position, and then rotating to sitting. The second is a partial rotation pattern incorporating rolling toward side lying and rotating up to a long- or side-sitting position. In the third, an adult sitting pattern is performed using symmetrical flexion from a supine to a long-sitting position. All three patterns and the refinement of any one are viable alternatives to helping someone relearn this activity. That knowledge base is drawn from a clinician's understanding of the normal motor development.

The pattern selected for use by a particular patient should be based on the preexisting neurological state of the client; the motor patterns in this activity that lead to greater independence in other ADL tasks; and the internal sensory, psychological, and motor state of the client. A clinician's understanding of CNS processing, both normal and after injury to various areas of the brain, should give valuable clues to selecting the most appropriate method for the client to use in moving from the supine to the sitting position. This knowledge is drawn from the second component of the model. External factors, such as time available and physiological and psychological needs of the patient and family, should be considered. Specific treatment modalities—such as stretch, resistance, inhibitory patterns, and touch—are selected to assist the client in learning the activity, depending on the clinician's understanding of the response of the CNS to various stimuli.

The method used to teach the client the activity (such as use of demonstration, choice of verbal language, and selection of long sequences or short steps) will depend on the client's preexisting learning styles and existing learning strategies and the clinician's skills in using various teaching methods. Thus, all three aspects of the model, no matter what the specific focus is, need to be considered simultaneously.

TREATMENT APPROACH

A problem-solving approach should be used when applying the model to clinical practice. The approach should stress 1) knowledge of the general clinical problems and their sequential nature, 2) evaluation that is ongoing from moment to moment, 3) goal setting that is determined by the client's basic level of function and the skill necessary to achieve the next highest level, and 4) treatment planning that focuses on the concept of sensorimotor integration and is based both on normal sequential development or learning and on a thorough understanding of sensory input and how it alters response patterns.

The specifics of treatment technique will not be discussed at length here. The general recommendations are to 1) use a classification schema for treatment procedures (eg, tapping, icing, and spinning) based on which specific sensory modality is used, \(^{11, 12}\) 2) incorporate the sequential nature of the development of various movement patterns, and 3) combine the use of the classification schema and the sequential development sequence.

CONCLUSION

Traumatic head-injured clients present a vast array of clinical problems. The range of involvement from total inability of volitional response to a stimuli to lack of highly integrated gross and fine motor ability creates a complex clinical environment. A therapist must have great flexibility to respond to the multiple individual needs of the client. Access to a clinical treatment model that incorporates any known treatment modality should provide the therapist with the necessary tools to address multiple problems. This article presented a model combining sequential behavioral development, internal neuromechanisms, and internal and external learning environments into one conceptual framework. The sequential development is based on analysis of behaviors and movement sequences necessary to carry out the activities normally. The rationale behind both using developmental sequences and specific facilitatory-inhibitory techniques as treatment procedures should be based on understanding of the brain and placed in a neurophysiological classification schema.
REFERENCES

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SUGGESTED READING