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Developmental Neuroanatomy and Physiology of Fetal Pain
Ohio Senate Committee on Health and Human Services
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SB 127: Pain-Capable Unborn Child Protection Act

Dear Distinguished Members of the Senate Health and Human Services Committee,

My name is Sheila Page, DO. I am an osteopathic physician, board certified in Neuromusculoskeletal Medicine. I have practiced for 23 years treating many patients with pain and various diseases, some at advanced stages. Although I treat patients of all ages, I have a special interest in children with disabilities and serious irreversible medical conditions, especially those who have little hope for recovery or improvement in their quality of life. I have found that the skills I developed over the years have enabled me to help improve their quality of life and ease their suffering.

The question that all physicians have heard many times before performing a medical procedure or treatment is "will it hurt?" Doctors go to great lengths to minimize and prevent pain for their patients. Requiring proof that a patient has pain before treating is in opposition to the ethical training of physicians. The physician anticipates pain in certain circumstances and protects people from pain whenever possible.

The discussion of fetal pain is centered on the definition of pain, which can alter the direction of the study of this topic. There are two general definitions of pain that appear in literature**:** the subjective perception, and the objective observation.[i]

The JAMA article (5) that has often been used as the authoritative paper proving that the unborn child does not feel pain uses a psychological definition: "Pain is a subjective sensory and emotional experience that requires the presence of consciousness to permit recognition of a stimulus as unpleasant." (Bioethics) This statement is a hypothesis that is dependent on subjective and negative data for its conclusion.

The basic science definition of pain is formed by objective observation: "Pain is a protective mechanism for the body. It occurs whenever any tissues are being damaged, and it causes the individual to react to remove the pain stimulus." (Guyton)

Neuroanatomy and Physiology

The three scientific classifications of pain:

1. Pricking pain is felt when a needle is stuck into the skin or when the skin is cut with a knife, or when widespread area of the skin is irritated.
2. Burning pain is felt when the skin is burned, can be excruciating, and is most likely to cause suffering.
3. Aching pain is a deep pain with varying degrees of annoyance. Aching pain of low intensity in widespread areas of the body can summate into very disagreeable sensation.

Each of these types of pain stimuli are carried along different neurofibers in the organism:

1) Pricking pain: carried along Delta type A fibers, fast
2) Burning pain: carried along type C fibers, slow
3) Aching pain: carried along type C fibers, slow

The pricking pain pathway produces a rapid response to pain at the spinal cord level and travels to the reticular activating system (reticular formation of brainstem and intralaminar nuclei of thalamus) where the majority of the pain fibers terminate. A few Type A fibers travel to the thalamus and connect there to synapse with the somatic sensory cortex for the purpose of localizing the pain. The burning pain pathway terminates diffusely in the reticular formation and in the thalamus, with very few connecting fibers to the cortex. It is characterized by gross localization and the ability to summate when large areas of the body are being damaged. The purpose of these pathways is to alert the individual that damage is being inflicted. Guyton, 1986, 2010 (illustration).

A variety of approaches have been used to study pain perception. The methods for eliciting perception of pain include:

1. Pricking the skin with a pin
2. Applying pressure against a bone
3. Pinching the skin
4. Heating the skin

One of the most reliable ways to measure a pain threshold is by gradually increasing heat applied to the skin. 'By far the greatest number of people perceive pain when the skin temperature reaches almost exactly 45C… Almost everyone perceives pain before the temperature reaches 47C." Across cultures this has been proven: there is very little difference in the threshold of pain perception, but there are wide variations in response to pain. [Guyton 1986, p 592-593]

The threshold at which pain is perceived (pain threshold), and the response to pain are different. As the human brain learns from various experiences and training, the response to pain may change and varies greatly with the individual.

Pain is directly correlated to tissue damage.

The point at which tissue begins to be damaged by heat is 45C, thus, the pain is correlated to tissue damage. "The intensity of pain has also been closely correlated to the rate of tissue damage by other effects besides heat," (contusion, chemical substances, infection, and ischemia). [Guyton 1986, p. 594.]

Another important characteristic of pain fibers is the non-adapting nature of pain receptors: in contrast to other sensory fibers, pain receptors adapt either not at all or almost not at all. "In fact… the threshold for excitation becomes lower and lower as the pain stimulus continues, thus allowing these receptors to become progressively more activated with time." This increase in sensitivity is called hyperalgesia. [Guyton, 1986, p. 593.]

The Sub-Cortical Neurological Pathways Involved in Pain Perception:

Type A and Type C pain fibers travel in the lateral division of the anterolateral pathway, remaining differentiated as fast or slow fibers. About three-quarters to nine-tenths of all pain fibers terminate diffusely in the reticular formation and in the thalamus (these two areas constitute the reticular activating system). The reticular formation is part of the medulla, pons, and mesencephalon.

Burning and aching pain fibers excite the RAS, thus activating the entire nervous system, causing arousal from sleep, creating a sense of urgency, and promoting defense and aversion reactions. The purpose of these pathways is to alert the individual that damage is being inflicted. Burning-aching pain is characterized by gross localization and the ability to summate when large areas of the body are being damaged. The summation property of the pain fibers in the RAS causes the most intense suffering in human experience. [Guyton, 1986, p. 596.]

Type A fibers enter the spinal cord, synapse with an interneuron, cross over and travel up in the anterolateral pathway. Very few Type A fibers pass directly to the thalamus and terminate in the ventrobasilar complex and posterior nuclear group via the spinothalamic tract. From here the connecting neurons to the cortex serve to localize the pain.

The pain perception functions remain in the lower centers and are not dependent on the cortex, although some modification of the pain threshold may occur. Pain impulses that enter and terminate in the lower brain centers, especially the reticular formation and the thalamus, can cause conscious perception of pain. [Guyton, 1986, p. 596.]

Consciousness and Pain

"Although the cortex may elaborate the contents of consciousness, it's not the seat of consciousness." Merker 2007. Merker (8), Brusseau (10), and Bellieni (9) agree that consciousness is not dependent on the presence of a cerebral cortex. These conclusions are reached by their individual clinical observations of conscious behavior in individuals without a cortex. Infants with hydraencephaly, in which little or no cortical fibers are present, demonstrate conscious recognition, pain perception, musical preferences, and alert, wakeful behavior. These represent a counter-example to the hypothesis that consciousness requires a cerebral cortex. The implication is rather that consciousness is a function of the lower brain centers. Further, ablation of the somatosensory cortex does not alter pain perception in adults, underscoring the anatomical implication that pain perception occurs in the lower brain centers. [Brusseau, p. 16.]

Embryological Concepts

The human being develops from a uniquely human single cell which comes into existence at the moment at which a human sperm penetrates a human egg. [M. Condic] The accumulation of biological data we have today clearly demonstrates that no developmental phase exists that constitutes a transition from the "non-human" to the "human". There is no scientific evidence for a stage in human development prior to birth in which one could claim that a being exists which is "not yet human". Human development is distinctly human and uniquely individual from conception. (6)

One of the scientific fallacies often repeated even today is the discredited concept of "phylogenetic recapitulation" or "ontogeny recapitulates phylogeny". This idea that the human

conceptus passes through evolutionary non-human phases in its development was first purported by Haekel, and supported by drawings and data which Haekel later admitted were fraudulent (Blechschmidt p.6). However, by the time that the fraud was admitted, the concept had become firmly entrenched in biology, and is even repeated today. (6) This falsely derived concept propagates the idea that the unborn human being is less than human, a concept not supported by scientific evidence.

One of the most accomplished scientists in the study of embryology was Eric Blechschmidt, (1904-1992), a German anatomist and physiologist who worked for more than forty years studying the development of the human form in principally the first eight weeks of life after conception. He produced more than 120 scientific papers and numerous books on the form and function of the developing human. Blechschmidt focused on the evidence presented by the embryo itself, producing more than 200,000 serial sections of embryos of different ages and sixty-four enlarged total reconstructions at the University of Göttingen.(6)

Blechschmidt's observations were unique in his whole body approach to the embryo. He considered the function of all parts of the developing embryo to parallel the structure. "The development of the central nervous system implies the simultaneous development of functioning afferent and efferent central pathways (tracts) and centers. Nothing has been found to support the idea that the function of the nervous system is added *after* the development of its shape and cell structure. It is the author's opinion that the function and structure develop simultaneously. The beginning of the nervous system implies the simultaneous beginning of function." (7) P.105

Observations of fetal movements at very early developmental stages supports the findings of Blechschmidt, that function and structure are developed simultaneously. "Neural cells begin to generate and propagate action potentials as soon as they interconnect. Furthermore, it has been shown that neurons are able to communicate through non-synaptic mechanisms even before the onset of synapsogenesis." [Salihagic, p.1]

Timeline of Development

The data on the chart below is a compilation of data from various sources, reflecting general agreement of the stages at which different structures have been observed to mature in the developing human.

Neurological Development of the Fetus:

WEEKS	Anatomical Structure Developed
7-20	nociceptors
8	cortex begins to develop
10-30	peripheral afferents
7.5	spinal reflex
20	spinothalamic connections
20-22	Thalamocortical tracts (cortical plate)
26-34	synapses of thalamocortical fibers

Development of the thalamus and corresponding structures is key to pain perception.

At 7.5 weeks, the spinal cord elicits a nociceptive response. The thalamus is already formed, and during the seventh week the thalamus rapidly expands (Moore. p.395) in conjunction with the developing nociceptive system of the spinal cord. Projections from the spinal cord...can reach the thalamus…from seven weeks gestation. Fitzgerald M. (17), Andrews KA, (18). The necessary components for pain perception are in place at this stage. It is important to consider that the function develops along with the structure. As Blechschmidt described, the brain and spinal cord are developing as a whole unit, functionally developing at the same time. Blechschmidt. The principal unit of pain perception is in place and rapidly expanding at 7.5 weeks.

Conclusion

The fetus is physiologically equipped to perceive pain, and demonstrates physiological responses consistent with pain perception. These responses are seen at 7.5 weeks and continue to develop until birth. It is reasonable to conclude that by 8 weeks the developing human is capable of pain perception. Our ability to relate to this possibility is limited by our own narrow vision, lack of understanding, and sometimes our unwillingness to perceive that which we cannot readily see. As physicians, we are obligated to anticipate potential suffering and take action to prevent or alleviate it.

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