Common Causes of Brain Damage

• Cerebrovascular Disorders = “Stroke”
• Tumors
• Closed-head injuries
• Infections
• Neurotoxins
• Genetic Factors

Cerebrovascular Disorders = “Stroke”

• May result from:
  – Cerebral hemorrhage
  – Bursting of an aneurysm (balloon-like dilation of a weak area of a blood vessel)
    • Aneurysms can be congenital (present from birth) or the result of infection, toxins, etc.
  – Cerebral ischemia
    • Thrombosis – a plug (ex. A blood clot, fat, cancerous cells, air bubbles) becomes lodged at site of formation
    • Embolism – a plug travels from the site of formation and becomes lodged in smaller blood vessels
    • Arteriosclerosis – blood vessel walls thicken and the space inside narrows

Arteriosclerosis

Ischemia and Excitotoxicity

• Brain damage during ischemia believed to result part from excessive release of glutamate
• Over-activates postsynaptic glutamate receptors, triggering an excessive influx of Na⁺ and Ca²⁺
• Damage produced by ischemia takes a while to develop and spread

Mechanisms of Neuronal Death After Stroke

Stroke Damage

What Can Be Done to Preserve Neurons?

• Remove clot
  – Surgically
  – Use tPA (tissue plasminogen activator) to break up the clot – must be given within 3 hrs of the stroke
• Experimental:
  – Block excitatory synapses
  – Stimulate inhibitory synapses
  – Block flow of calcium and zinc
  – Cool the brain

Brains On Ice

Brain Tumors
11  Closed-head Injuries
  • *Contusion* – damage to the cerebral circulatory system producing internal bleeding, and ultimately a hematoma
  • Contusions occur when the brain slams against the inside of the skull
  • Contusions frequently occur on the side of the brain opposite side of the head where the blow occurs
  • Blood can accumulate in the subdural space (between the dura mater and the arachnoid membrane)

12  Trepanation – Boring a Hole Through the Skull

13  Closed-head Injuries
  • *Concussion* - a disturbance of consciousness with no evidence of contusion or other structural damage
  • *Coma* - a complete loss of consciousness

14  Punch-drunk Syndrome

15  Brain Infections - Encephalitis
  • Bacterial Infections
    – E.g. Syphilis - infecting bacteria may go dormant for several years before they become virulent and attack many parts of the body including the brain – a syndrome of insanity and dementia may result if left untreated

16  Brain Infections - Encephalitis
  • Viral Infections
    – Viruses with a particular affinity for the nervous system
      • E.g. Rabies - takes time to attack the brain (at least a month) - produces fits of rage and ultimately death
      • E.g. Polio - preferentially attacks motor neurons
    – Viruses that can attack the nervous system, but have no special affinity for it
      • E.g. Mumps, measles, herpes
      – Some mosquito- and tick-borne illnesses
      • E.g. West Nile

17  Neurotoxins
  • Brain damage can be produced by a variety of toxins in the environment
    – E.g. Mercury - “Mad hatters” were the victims of mercury poisoning
    – E.g. Lead - “Crackpots” were originally those who drank tea from cracked ceramic pots with lead cores
  • Sometimes drugs used to treat a disease can have neurotoxic effects
    – Tardive dyskinesia (tremors and other involuntary movements) can be produced by exposure (ranging from a few days to more than 20 years) to certain antipsychotic medications

18  Genetic Factors
  • Some genetic disorders are accidents of cell division (ex. In Down syndrome an extra chromosome in pair 21 is present in all cells – produces retarded intellectual development)
  • More commonly, genetic disorders are products of abnormal genes (these are usually recessive)
19  Neuroplastic Responses to Nervous System Damage
   • Degeneration
   • Regeneration
   • Reorganization

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25  Mechanisms of Recovery After Brain Damage
   • Promoting Regeneration
     – Regeneration of spinal cord
     • Transplantation of myelinated PNS nerves promoted growth of spinal cord neurons through the implanted Schwann cell myelin sheaths (make growth factors and cell adhesion molecules)
   • Neurotransplantation
     – Fetal Tissue
     • Fetal substantia nigra cells have been implanted in striatum of Parkinson’s patients
     – Stem Cells
     • Still in early stages
     • Cells are pluripotent (can develop into many types of mature cells)
   • Rehabilitative Training

26  Phantom Limb Sensation & Rehabilitative Training
   • About 50% of amputees experience a continuing sensation of the amputated body part
   • Until the 1990’s, it was generally believed that the sensations were coming from the stump
   • We now know that reorganization of the somatosensory cortex is responsible - the greater the reorganization the more likely and more intense the phantom sensations

27  The MAP of the Somatosensory Cortex Explains Why Touch In Some Locations Can Elicit Phantom Limb Sensation

28  Training Can Facilitate Additional Reorganization Of The CNS
   • Phantom limb sensation can range from occasional tingling to intense pain
   • Sometimes the sensation fades within days or weeks, but it can last a lifetime
   • If the phantom sensation is painful, training can help
   • E.g. Sensation of fingernails digging into the palm - relax the “phantom hand” by relaxing the image of the hand

29  Neurotrophic Factors