Forensic Evaluation of Sea Turtle Injury

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Sea TuRTLe CSI

WHAT HAPPENED? CAN IT BE PREVENTED?
Trauma accounts for 25% of strandings in Florida over the last 10 years. Of these only 12% strand alive.

The first step in assessment is accurate documentation by narrative descriptions, diagrams, and photographs.

- cell phone images are usable quality
- standardized stranding report
- database management

By convention, "acute mortality" is within 24 hours of injury.
Aging of injuries

3 stages of healing

Inflammation (1-7 days)
reddening and rounding up of wound margins, active bleeding

Proliferation phase (1-3 weeks)
Purulent exudate, proliferation of fibrous granulation tissue

Reorganization/remodeling (3 weeks - months)
Well developed granulation tissue with pigmentation

Green turtle, boat propeller

Postmortem changes

Decomposition changes (the 4Ds)
- Discoloration * Livor mortis (gravitational settling of blood that distends capillaries and veins)
- Distention
- Degradation
- Dissolution

Predation
Soft tissue defects with no evidence of inflammation (histopathology may be needed)
**Biomechanics of injury**

**NEWTON’S 2ND LAW**

\[ \text{FORCE} = \frac{\text{MASS} \times \text{VELOCITY}^2}{2g} \]

where:
- \( g \) = acceleration of gravity (32.16 ft/sec\(^2\))

*Important to note:* An increase in mass will increase force by a factor of 2, while an increase in velocity will increase force by a factor of 4.

In ballistics terms:
- Low velocity injury <1000 ft/sec
- Medium velocity injury 1k-2k ft/s
- High velocity >2k ft/sec

High performance motor-craft attain medium velocity. Gunshot wounds will vary with type of weapon.

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**Swordfish long-line hook**

**Kemp’s Ridley, chronic long-line fishing hook**

**Biomechanics of injury**

**tension = pulling apart**
Low velocity injuries are primarily due to crushing and laceration (Green turtle, acute shark bite).

Medium and high velocity will create crushing and laceration but also generate shock-waves and cavitation injuries as the energy is translated through the body. (Loggerhead, acute boat propeller).

BIOMECHANICS OF INJURY: LACERATION AND CAVITATION

LACERATION = CRUSHING AND COMPRESSION OF CAVITIES

CAVITATION = CREATION OF CAVITIES

BIOMECHANICS OF INJURY: CONSTRUCTION

TOURNIQUET EFFECT

TISSUE DESTRUCTION

LOSS OF BLOOD SUPPLY

biomechanics of injury  constriction

Loggerheads, mono-filament fishing line entanglement
ANATOMY OF A PROPELLER

sharp force = lacerations from propellers, scrapes from skegs

RIGHT HAND PROP = CLOCKWISE ROTATION
LEFT HAND PROP = ANTI-CLOCKWISE ROTATION

*Wound development is dependent on boat configuration, speed, and trim of engine.

DEEP VEE, MOST COMMON POWERBOAT HULL, NEEDS LARGE ENGINE

FLAT BOTTOM, SLOW SPEED, CALM WATER

ROUND BOTTOM, MOVE EASILY (SMALL ENGINE)

MULTI-HULL, CATAMARANS. POORLY MANEUVERABLE, VERY STABLE

blunt force = from hulls, keels, rudders, propeller blades, and skegs

ANATOMY OF A BOAT HULL
OUTBOARD MOTOR: MOUNTED TO TRANSOM. SKEG CONTROLS DIRECTION (DEEP TO PROP)

INBOARD MOTOR: MOUNTED INSIDE BOAT. DIRECTION CONTROLLED BY RUDDER (BEHIND OR BESIDE PROP)

STERN DRIVE: I/O MOTOR, MOUNTED INSIDE, PROPELLER CONTROLS DIRECTION

Sharp force injuries

- incision = length of skin wound > depth of skin wound
- stab = length of skin wound < depth of skin wound
- Propellers have an edge but no point so wounds are considered incisions; shark teeth have a point but no edge so wounds are considered stabs.

Loggerhead, plastron, acute shark bite
Blunt force injuries

*LACERATION = TEAR IN DERMIS, HAS IRREGULAR MARGINS WITH STRANDS OF TISSUE OFTEN BRIDGING DEFECT
*CONTUSION = BRUISE "CLOSED" INJURY
*ABRASION = SCRAPE, SUPERFICIAL SKIN LAYERS REMOVED BY FRICCION, COMPRESSION, OR STRETCHING

loggerhead, acute flipper laceration

green, plastron contusion, week old abrasions

Water-craft injuries

* single, linear lesions are consistent with skeg trauma. repeating, almost evenly spaced incisions are consistent with propeller trauma.

* wound axis drawn thru the center of each cut in the pattern and is parallel to the direction of travel of the water-craft.

* cut span is distance along the wound axis from leading edge to leading edge.

Loggerhead boat propeller and skeg
Water-craft injuries

*angle of blade to cutting surface will result in varying injuries, important to note as victim position will change after the initial force is applied. (water provides very little resistance).

LOGGERHEAD, ACUTE BOAT PROP AND SKEG INJURY

*Note blue hull paint on barnacles

LOGGERHEAD, 4 MONTH OLD BOAT PROP INJURY

Water-craft injury

*direction of force can be determined in soft tissue -- abrasions and lacerations (abraded layers of skin will be pushed to one side, unequal undermining due to tangential force

* in bone --highly comminuted (fragmented) carapace fractures indicate greatest absorption of kinetic energy at that site—point of impact.

Loggerhead boat hull trauma

DIRECTION OF FORCE
Shark bite injury

- Crescent shaped lacerations with tremendous soft tissue defects.

Loggerhead, 2-3 week old shark bite

Shark bite injury

* Many tooth marks typically evident on shell as it rarely is single bite wound

* Often accompanied by massive soft tissue defects and blood loss

green, acute shark bite

Loggerhead, chronic, shark bite
Cavitation injury is greatly affected by the specific gravity of the tissue that has been struck (highly dense tissue such as bone is more greatly affected).

- Explosive effect on bone drives splinters forward, ahead of the force, increasing the magnitude of soft tissue injury.
- Also, greater fragmentation (comminution) occurs where cortical bone predominates.

“The retentive forces that combat the disruptive forces of injury also vary with the tissue struck.”

VISCOUS TOLERANCE = RESISTANCE OF AN ORGAN TO COMPRESSION AND VELOCITY. INVOLVES TENSILE STRENGTH, RESILIENCY, AND COHESION.
Dermis

Scales = thickened areas of epidermis and keratin covering the skin and head.

Scutes = keratinous plates covering the shell.

The tensile strength of the skin must be exceeded for penetration of the skin to occur (related to both elasticity and thickness).

Because tensile strength is so high, sharp objects are also capable of blunt force trauma.

Loggerhead, acute boat propeller

Dermis

Leatherbacks: leathery shell composed of skin overlying a mosaic of thin bony plates. Deep to bone is a dense blubber layer composed of fibrous connective tissue and fat.

Chelonids: bony shell covered with distinctive scutes, no blubber layer is present. Deep to skin is fibrous, elastic connective tissue and compartmentalized fat stores.

Leatherback, chronic boat propeller and skeg

Loggerhead, chronic boat propeller
Axial skeleton is made up of thin layers of cortical bone sandwiching cancellous bone. Cortical layers are thicker at the peripheral bones of carapace.

C8-T10-S3-Ca12+ C7 and C8 are fused, cervical vertebra form a dense, short complex. This inter-digitation allows for dorsoventral bending but little twisting. Sea turtles cannot retract the neck.

Skeleton

Skeleton

APPENDICULAR SKELETON IS CORTICAL BONE (VERY THICK LAMELLI) OVER CANCELLOUS MEDULLA WITH THE EXCEPTION OF LEATHERBACKS THAT ARE VIS VERSA.

Bones are osteosclerotic, as turtle ages the density of bone increases due to replacement of trabecular bone by compact bone.

Nutrition may influence bone density greatly.

Vertebral bone in contrast to humerus of same Loggerhead
Lungs: Saccular lung, no chambers supported by cartilage, no secondary bronchi. Spongy faveoli and ascini (no alveoli).

Wide dorsal attachment to carapace and medial attachment to vertebral column with tough, fibrous connective tissue.

Posteriorly, the lungs attach to the peritoneum that overlays the kidneys and adrenal glands with another expanse of fibrous connective tissue.

Narrow ventral attachments on right to liver via hepato-pulmonary ligament and on left to stomach via gastro-pulmonary ligament.

Energy absorbed by these elastic, compliant, large, gas, filled structures prevents shock-wave injury to viscera. Internal airbag.

Differential displacement at ventral attachment points results in shear stress and predisposes to injury at these sites.

Injury to lungs may result in open pneumocoelom (free communication between pleura and environment) or closed pneumocoelom (internal air accumulation as result of leakage).
Viscera:

- In situ examination is very important in order to investigate the relationship between external injury and internal trauma (laceration of gut may correspond to propeller pattern on carapace)
- Kidneys are highly predisposed to injury due to location. Renal hematomas are commonly seen inside the capsule.

Gravid Female

- ovaries are paired and posterior to lung
- especially prone to injury due to weight and hydrostatic pressure of eggs.
- oviduct is a muscular, mobile, thin walled tube
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