

# **Stunning Systems for Poultry**

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**R. Jeff Buhr & Daniel L. Fletcher**

**February 28, 2003**

**Kansas City, MO. AMI**



# **Stunning of Poultry**

**WPC 2000**

## **Gas Stunning and Its Effect on Animal Welfare**

**GPC 2002**

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**Daniel L. Fletcher**

**Department of Poultry Science**

**University of Georgia**

**R. Jeff Buhr**  
**Research Physiologist**

**Poultry Processing & Meat Quality**  
**Russell Research Center**  
**Athens, Georgia**  
**USDA-ARS**

# Presentation Area of Focus

- transport

- 
- unloading

- shackling

- **stunning**

- **neck cutting**

- **bleeding**

< 2  
min

– electrical stimulation

- 
- scalding

2.5 to 5  
minutes

# Stunning

## - Topical overview -

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- Historical & Modern perspectives
- General concepts
- Welfare
- Electric or Gas
- Recent developments

# Stunning

## - Historical perspective -

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- Initially Human welfare concerns working with large animals (concussion)
- Humane Slaughter Act - 1958 US
- Humane Methods of Slaughter Act - 1978 US
- Slaughter of Poultry Act - 1967 UK

# Stunning

## - Historical perspective -

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Humane Slaughter Acts - 1958 & 1978

Automated stunning of poultry -1943

1. Render animals insensible to pain prior to bleeding
2. Breathing stops prior to entering scald
3. Instantaneously rendered insensible to pain until death supervenes - EU



# Stunning

- Historical perspective -

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-Why stun poultry at all?

1. Facilitates automated killing systems
2. Minimizes carcass damage (No stun)
3. Human welfare
4. Animal welfare concerns

# Stunning

## - Modern perspective -

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- Greatly increased importance of Animal Welfare issues
  - Public policy / regulations / market demands
- Stunning current impacts carcass damage
  - Hemorrhages & broken bones

# Stunning

## - Modern perspective -

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- Current alternative stunning systems
  - Electrical
    - AC / DC, frequency, current, stun-to-kill
  - Gas (chemical)
    - Carbon dioxide, argon
  - Mechanical (concussion)

# Stunning

## - General concepts -

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- Renders the animal unconscious
  - Reduced unconscious muscular activity
  - Malleable for automation
- Recoverable - “stunning”
- Unrecoverable - “killing = electrocution”

# Stunning

## - General concepts -

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- Disrupts brain function - cerebral cortex
  - Loss of consciousness
  - Loss of ability to perceive pain
- Recoverable - temporary short circuit
- Unrecoverable - permanent damage

# Stunning

## - Requirements -

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- Time onset - “instantaneous”
  - Hard to define
- Duration - sufficient that animal does not regain consciousness prior to death

# Stunning

## - Requirements -

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- Zero tolerance for missed birds
- **Must be humane**

For the animal and aesthetic for human

# Stages of Anesthesia

- Conscious-Unconscious-Death -

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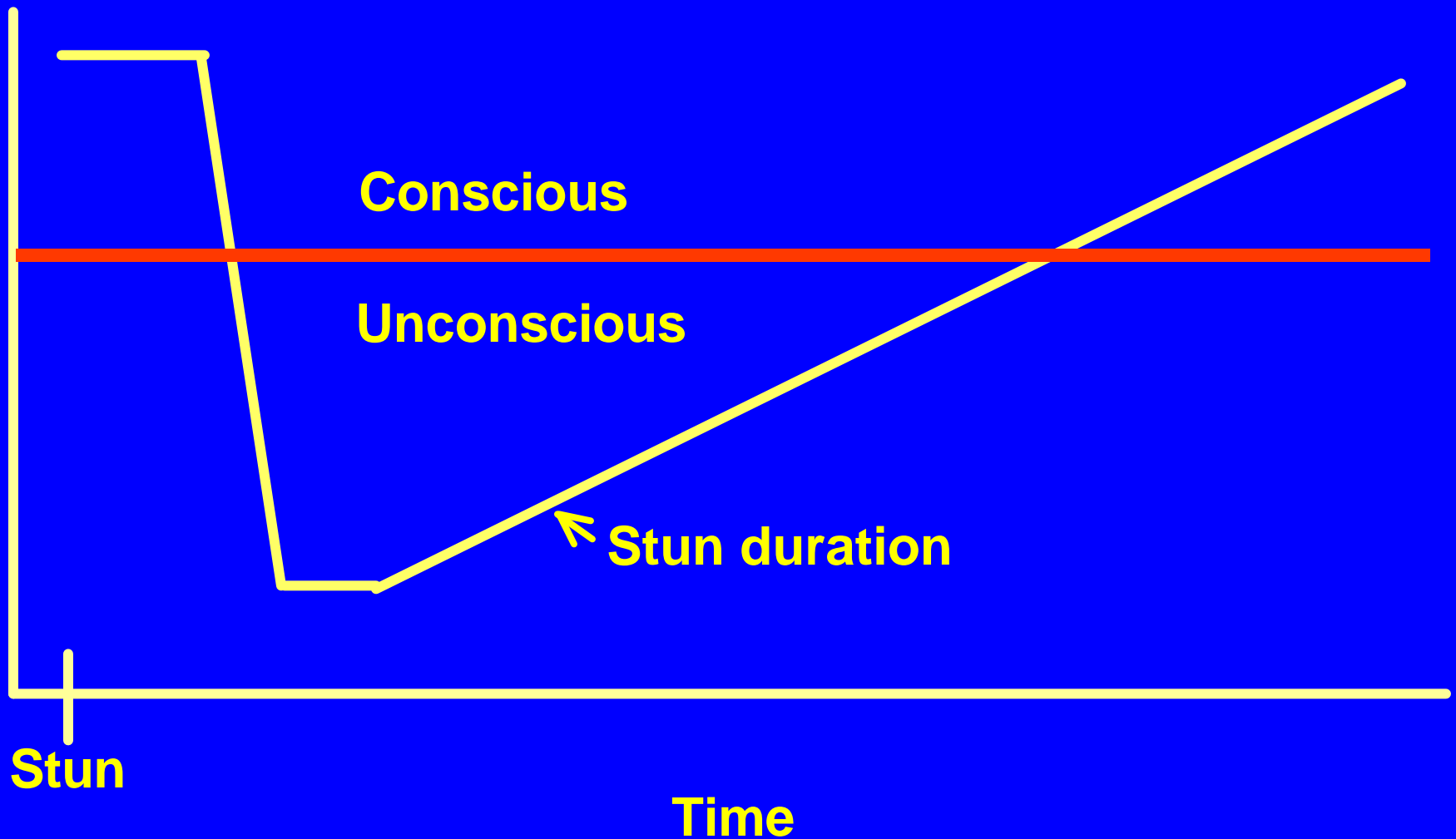
1. Analgesia - Pain relief, disorientation
2. Unconscious, Delirium - Reflexes present
3. Surgical Anesthesia (4 planes)
  1. Light - Muscle relaxation
  2. Medium - Sluggish reflexes
  3. Deep - Diminished reflexes, Respiration (-)
  4. Overdose - All reflexes absent
4. Medullary Paralysis - No Respiratory, cardiac

**Guedel, 1937**

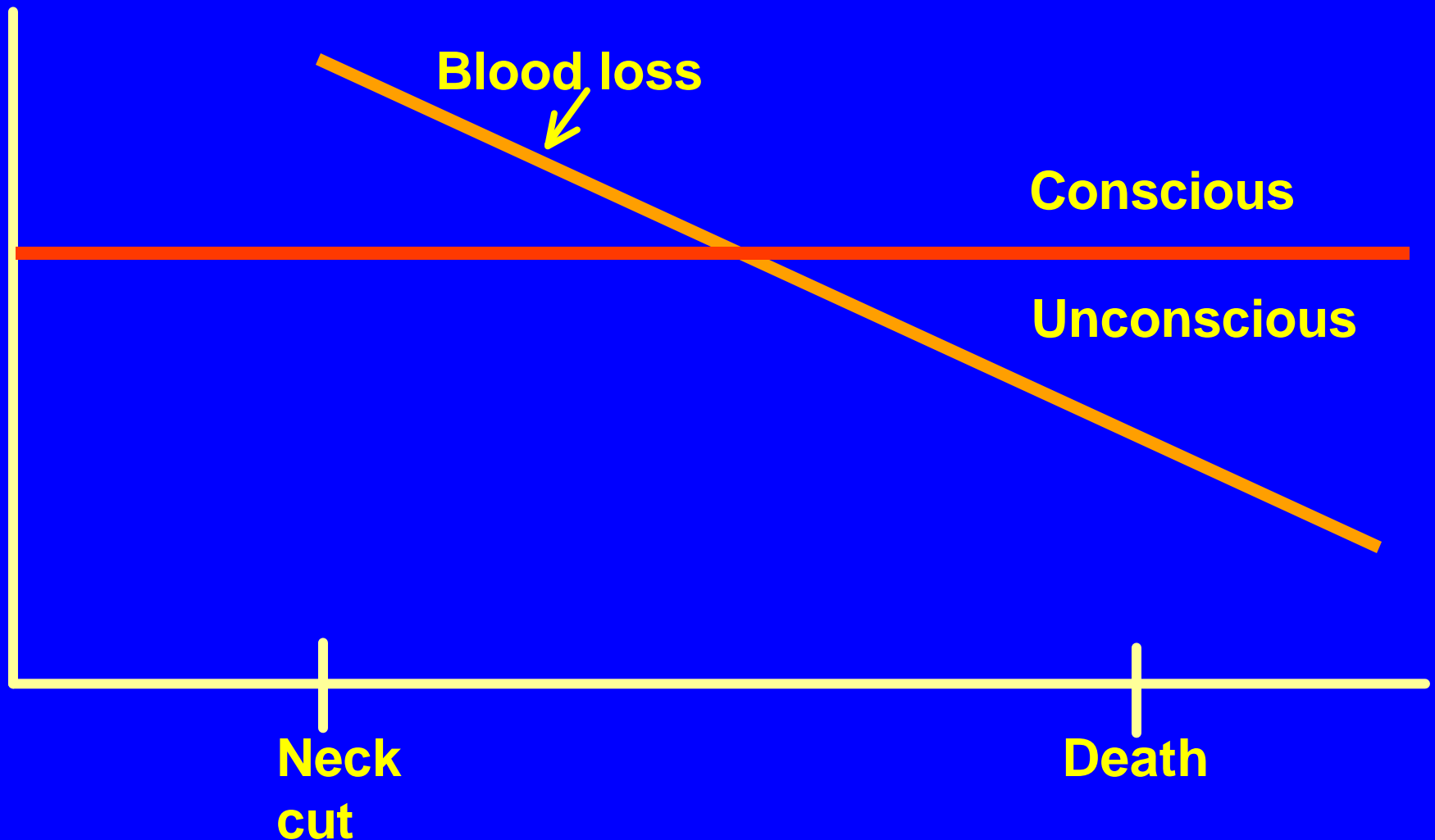
AMI-2



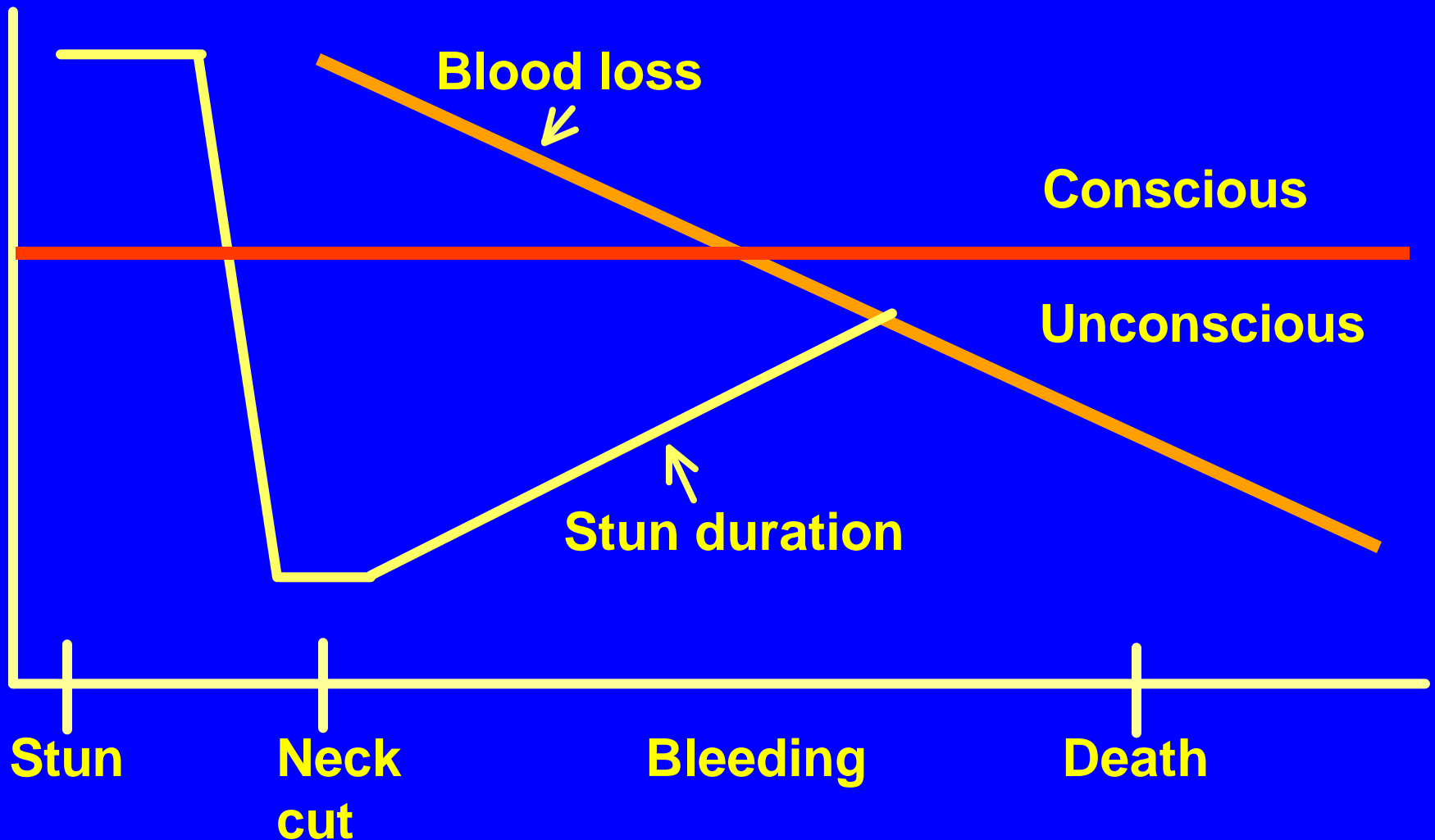
# Electrical Stunning and Recovery



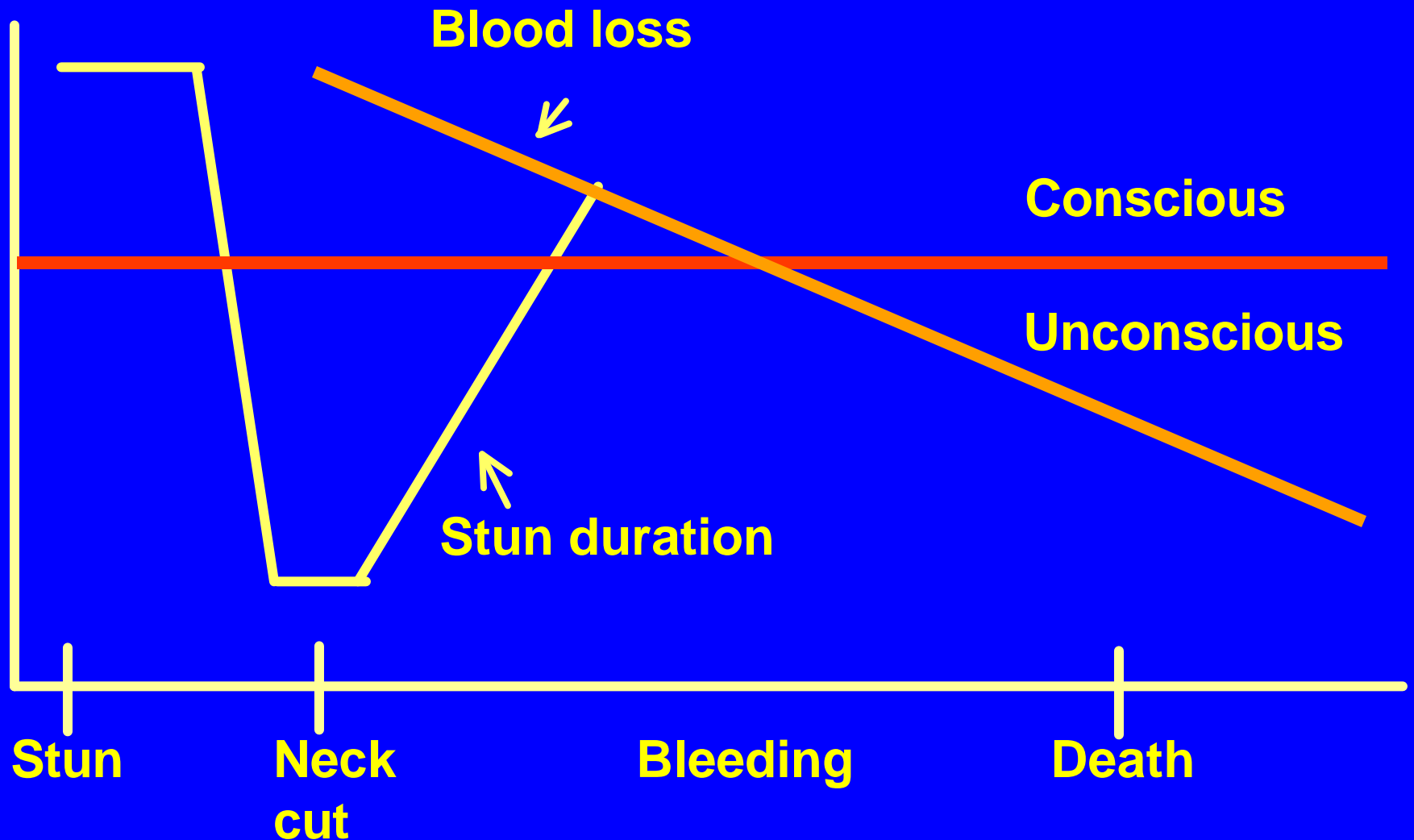
# Blood Loss and Consciousness



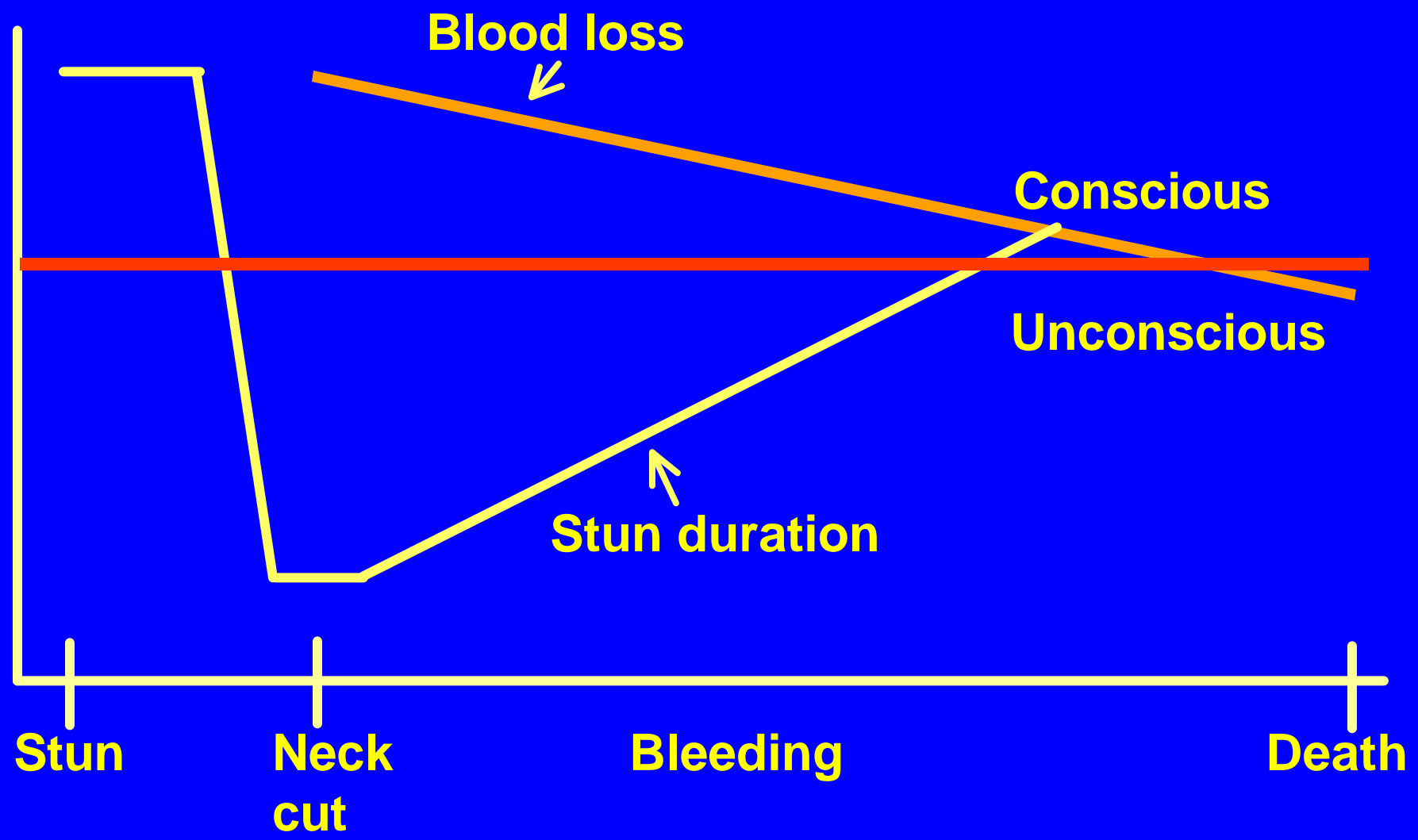
# Proper stunning and bleeding



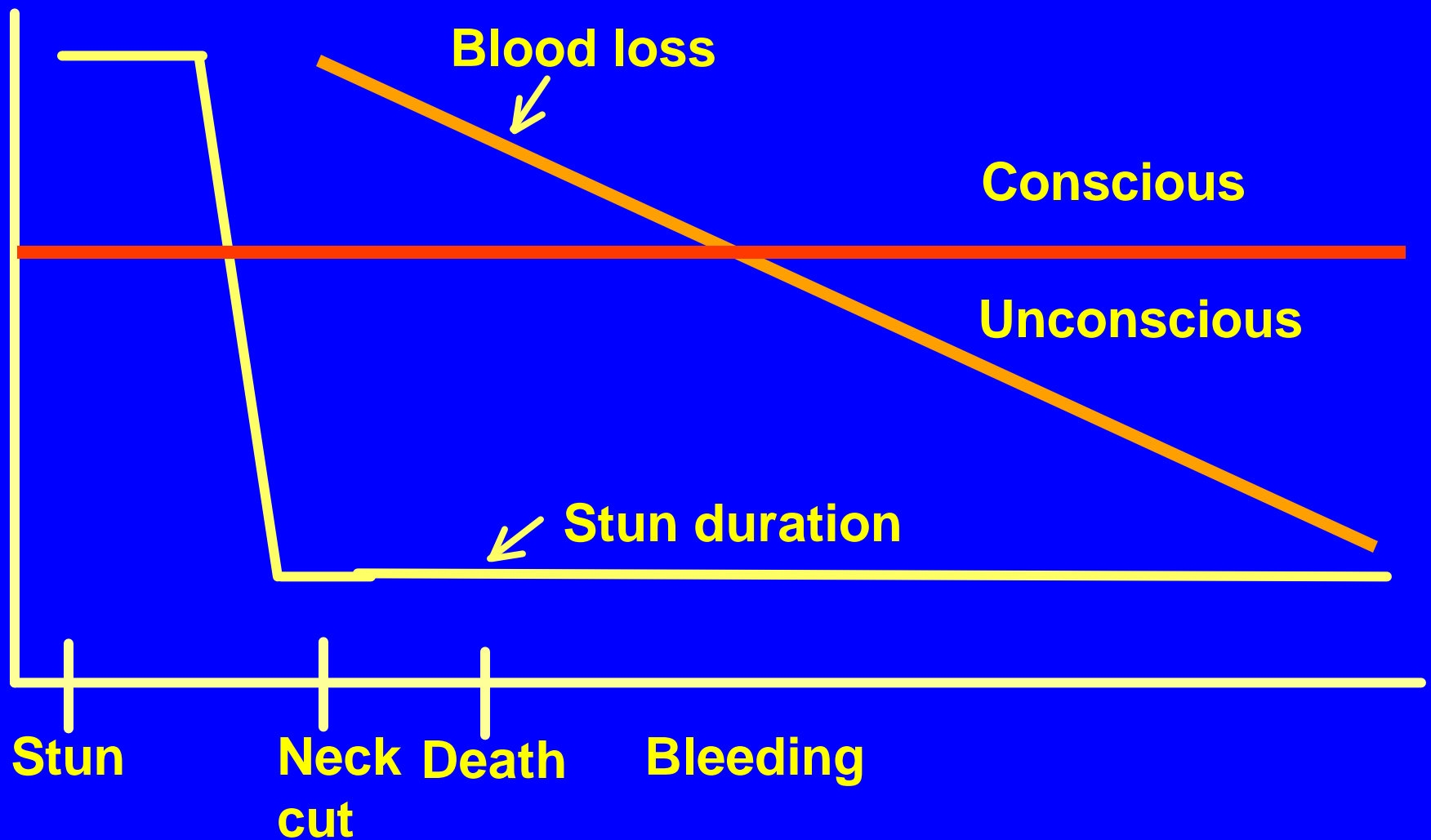
# Poor stunning and proper bleeding



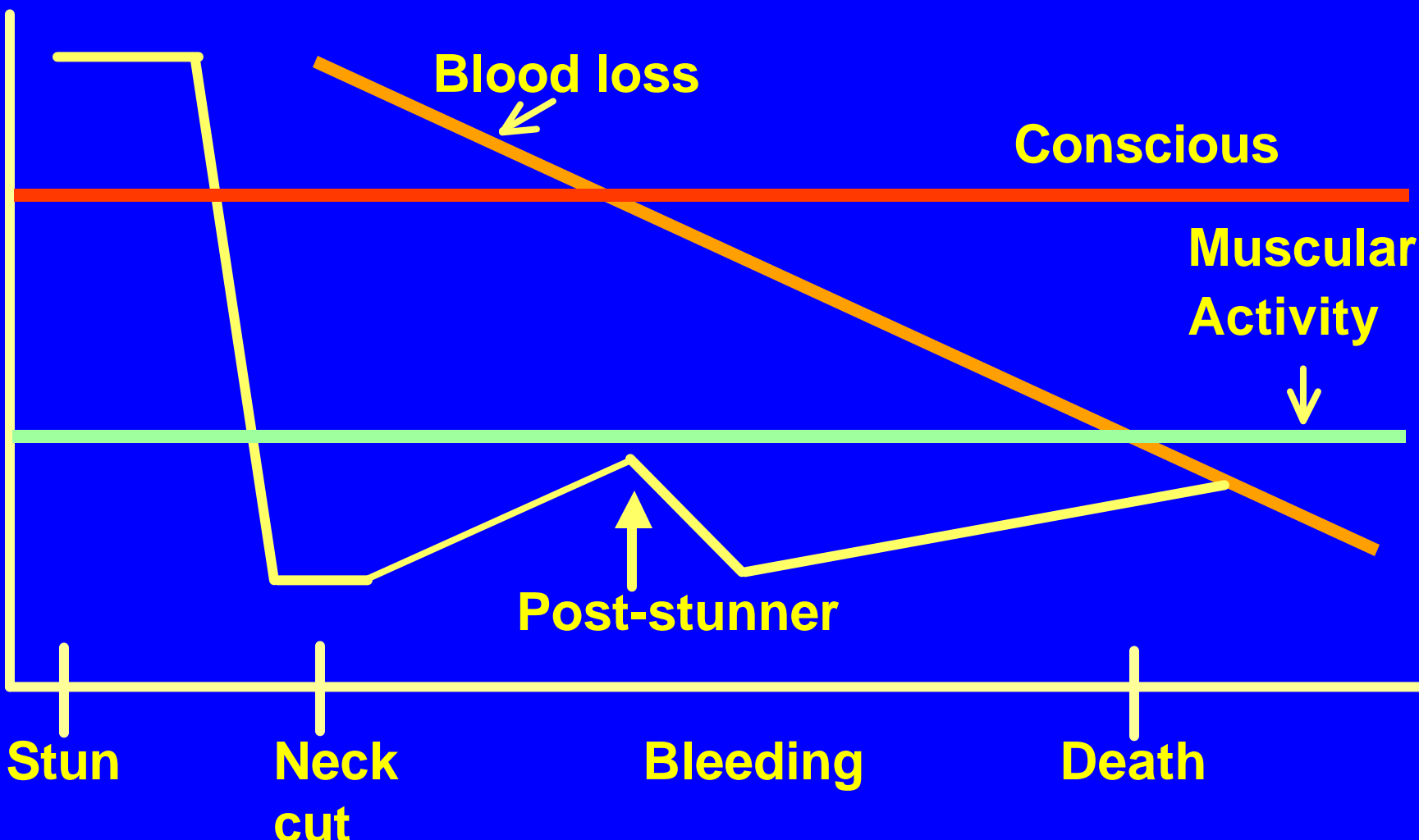
# Proper stunning but poor bleeding

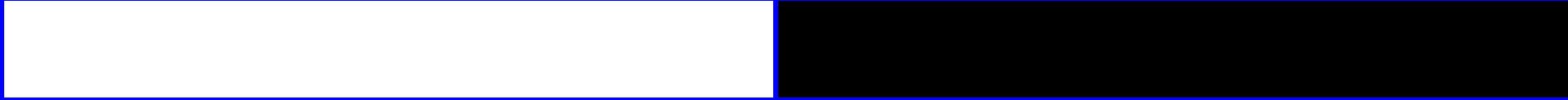


# Stun-to-Kill



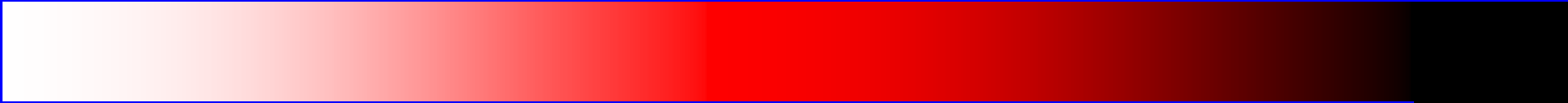
# Carcass muscular activity post-stun





**Alive**

**Dead**



**Alive**

**Unconscious  
but able to  
self-resuscitate  
(stunned)**

**Unconscious  
but unable to  
self-resuscitate  
(respiratory failure,  
cardiac arrest)  
-electrocution**

**Dead**



**30 seconds to 2+ minutes**

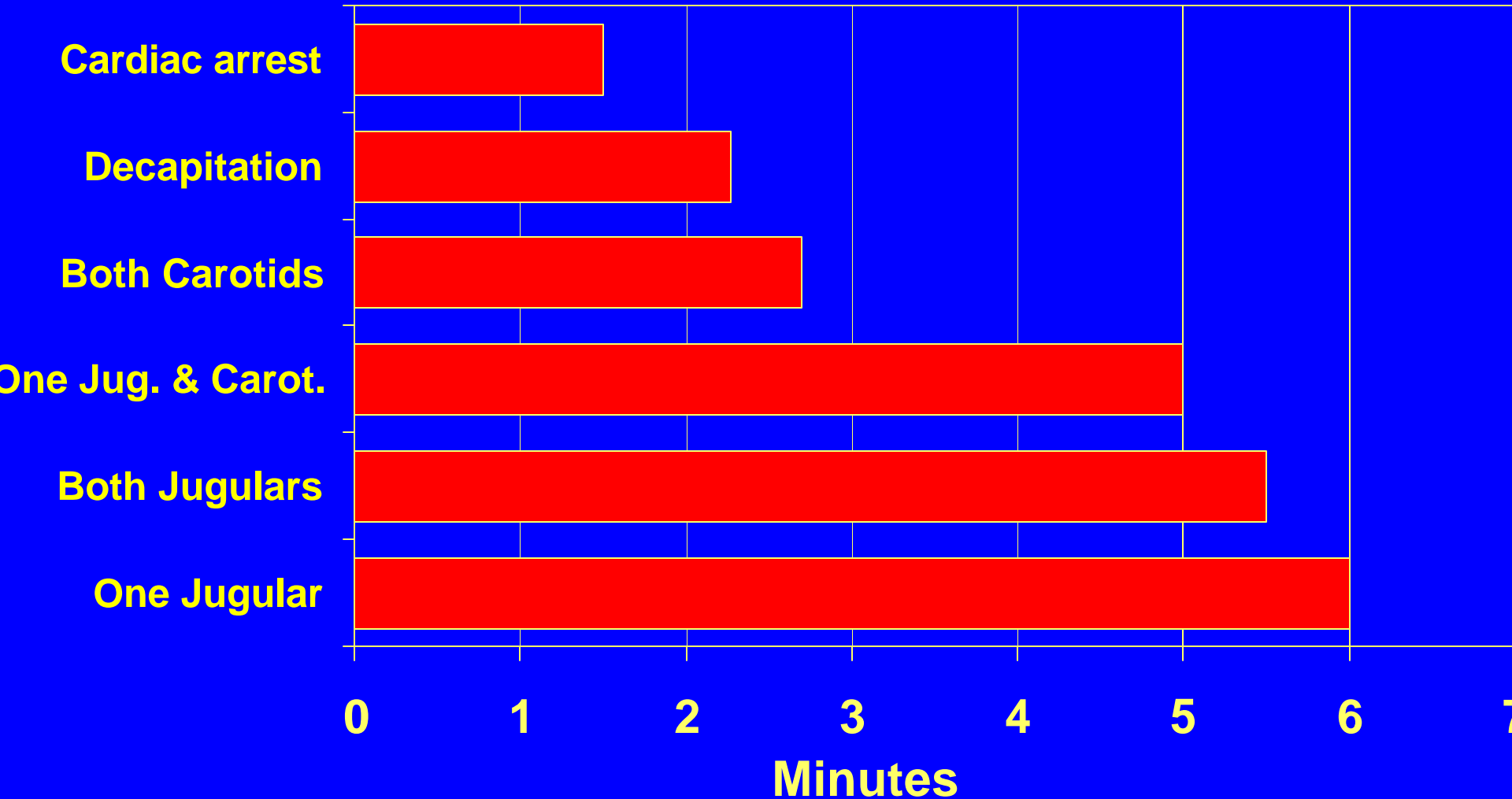


# Stunning *versus* Killing

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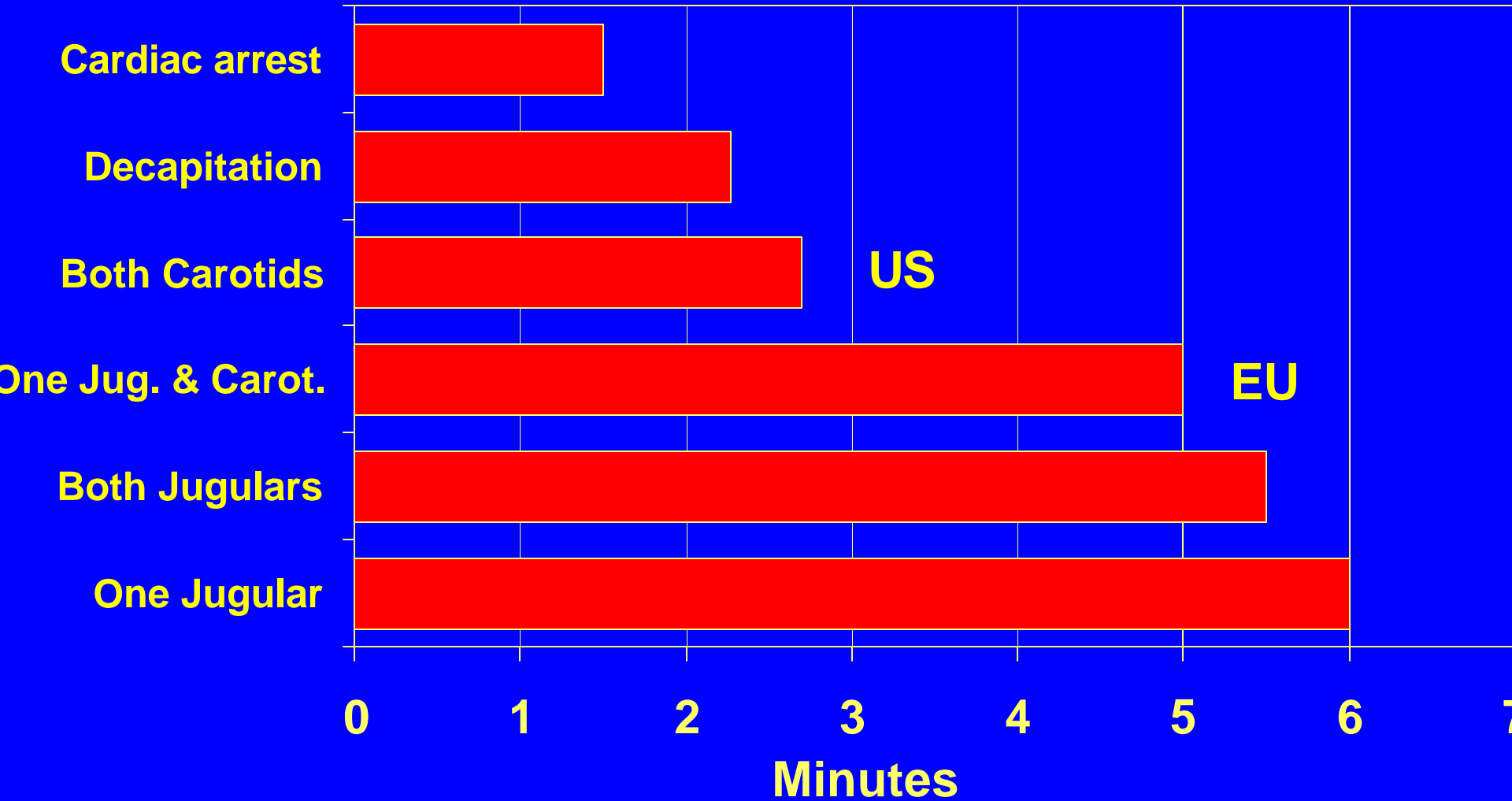
- Stunning renders the animal unconscious but is recoverable
- Status of the animal between stun and death is ambiguous, depends if “stun” is recoverable or non-recoverable
- Stunning and killing need to be considered to be integral steps in a single process as opposed to independent operations

# Method of Slaughter - Time to Brain Functional Failure



(From Gregory and Wotton, 1986)

# Method of Slaughter - Time to Brain Functional Failure



(From Gregory and Wotton, 1986)

# Who's Welfare is it?

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- Animal welfare - what's least traumatic or painful for the animal
- Human welfare - what causes the least anxiety in the consumer
- Corporate welfare - market viability

# Animal Welfare / Humane Death

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## Not scientifically defined or agreed upon

- Conscious - able to perceive pain
- Unconsciousness - not able to perceive pain

## **Emotional, Anthropomorphic, and Aesthetic Issues (Appearance)**

- Human welfare (conscience)

# Electrical Stunning

## - Advantages -

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- **Efficient**
  - Quickly renders the animal unconscious and malleable for automated bleeding
- **Economical**
  - Low capital cost, simple, low maintenance, and low operation cost

# Electrical Stunning

## - Advantages -

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- Fast

- Ideal for high-speed, in-line flexible application

- Carcass and Meat Quality

- Reduces peri-mortem struggle (death)

# Electrical Stunning

## - Disadvantages -

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- Welfare
  - Inconsistent application
    - Variability between birds / size
  - Stun duration
    - May regain consciousness with poor bleed
- Carcass and meat damage (high current)
  - Broken bones, hemorrhages, poor bleed-out



# Problems with Electrical Stunning

## - Welfare Issues -

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1. Failure to adequately and consistently stun the bird
2. Insufficient duration such that the bird regains consciousness
3. Undue distress relative to induction of the electrical stun

**Gregory, 1989**

# Electrical Stunning

## - European response -

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- Up to 30% of birds appeared under stunned (muscular movements)
- Recommendations:
  - 105-125 mA 50Hz
  - Irreversible stunning = electrocution

# Electrical Stunning

## - European response -

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- 50Hz induces ventricular fibrillation (cardiac arrest)
- Similar problems not present in USA
  - Different killing methods

EU = Unilateral - one Carotid a & Jugular v

US = Bilateral - both Carotid a & Jugular v

# Electrical Stunning

## - European Problems -

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1. Greatly increased carcass damage  
hemorrhages, carcass and meat defects
2. Perceived conflict between Welfare and  
Carcass Quality
3. Therefore the need to develop alternative,  
welfare friendly stunning-killing systems

# Alternative Stunning Systems (alternative to high current killing)

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- **Modified electrical stun-killers**
  - Constant current, individual bird, head only, high-frequency
- **Gas - stunning and killing**
  - CO<sub>2</sub>, Argon/CO<sub>2</sub>, CO<sub>2</sub>/ O<sub>2</sub>, N<sub>2</sub>
- **Mechanical (not common)**
  - Captive bolt, compressed air

# Alternative Stunning

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1. Major issue in Europe due to carcass damage from high current stunning
2. Search for stunning-killing systems that are both humane and reduce carcass and meat damage
3. Comparisons therefore are most often made between high current killing to the alternative system

# Alternative Stunning

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## Not a major issue in United States

1. No similar situations relative to under-stunned birds
2. Use of low voltage systems that do not cause excessive carcass damage
3. Use of ventral neck cut
  - Bilateral Carotids arteries & Jugulars veins

# Electrical Stunning

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- Under stunning
  - Increased muscular activity, carcass damage, missed neck cuts, birds entering scalders with functional brain = cadaver
- Over stunning
  - Electrocuted birds, slower bleed-out, carcass damage-hemorrhage and broken bones
- Proper stunning
  - Unconscious birds, wings tucked, easily manipulated for auto-killing, high percentage with proper neck cut, good bleed-out, reduced muscular activity



# Electrical Stunning

## - Developments -

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- **Electrical Current**
  - AC *versus* DC
  - High current
    - “stun-to-kill” 105 to 120 mA per bird
  - Constant current
- **Frequency**
  - At both high and low current
  - CNS versus Skeletal & Cardiac muscle

# Electrical Stunning

## - Developments -

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- **Individual bird stunning**
  - Control of current for each bird
- **Head only stunning**
  - Avoid carcass damage
- **Low voltage stunning**
  - 12 to 14 volts
- **Stunning time**
  - 3-5 sec. up to 12-14 sec.

# Electrical Stunning

## - Developments -

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- **Multi-stage stunning**
  - Integrated 2-stage
    - 12 - 14 V, pulsed DC, 500 Hz, 8 - 12 sec.
    - 14 V, AC, 60 Hz, 2 - 5 sec.
- **Post-stunning - AC**
  - Primarily turkeys to improve bleed-out

# Electrical Stunning

## - Future improvements -

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- **Stunner design**
  - Reduce pre-stun shock
  - Better “capture” of all bird
- **Rigor development rate**
  - Effect on rate and severity of rigor
    - processing efficiency
    - meat quality

# Gas Stunning

## - Terminology -

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- Stunning *versus* killing (stun-kill)
- “modified atmosphere killing”  
**(MAK)**
- “modified atmosphere stunning- killing”  
**(MASK)**
- “controlled atmosphere” stunning  
**(CA)**

# Gas Stunning

## - Basics-

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- Deprivation of oxygen to the brain
- Fine line between “stunning” and “killing”
- Good Ergonomics / Low carcass damage
- Combination of gasses available
- Costly to install and operate
- Specialized bird handling systems

# Gas Stunning

## - Basics -

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- Typically counter flow:
  - Entrance 40% CO<sub>2</sub>, Final 60% CO<sub>2</sub>
- 90% Argon / 10% Air
- 60% Argon / 30% CO<sub>2</sub> / 10% Air
- CO<sub>2</sub> / O<sub>2</sub>

# Gas Stunning-Killing Systems

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## System 1

Unloading

Shackling

Gas

Neck cut

Bleeding

## System 2

Unloading

Gas

Shackling

Neck cut

Bleeding

## System 3

Gas

Unloading

Shackling

Neck cut

Bleeding



# Electrical vs. Gas Stunning

## - Issues -

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### 1. Humane slaughter

- Welfare status not established for gas
- Regulatory constraints - instantaneous?
- Market demands - retail or fast food

### 2. Product quality - EU vs. US

- Improved carcass and meat quality defects (compared to high current killing)

# Electrical vs. Gas Stunning

## - Issues -

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### 3. Worker issues

- Worker environment: ventilation, light, etc.
- Worker safety / ergonomics (**turkeys**)

### 4. Processing plant and live haul constraints

- Additional room for gas stunning system
- Identify DOAs
- Throughput and line speed flexibility
- Integrated catching through slaughter

# Electrical vs. Gas Stunning

## - Issues -

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### 5. Economics

- Capital expense and operation
- Costs *versus* benefits?
  - EU versus US very different

### 6. High tech *versus* low tech

- Complexity of gas killing systems
- Worker availability, training & skill level
- Safety

# Stunning

- Recent developments -

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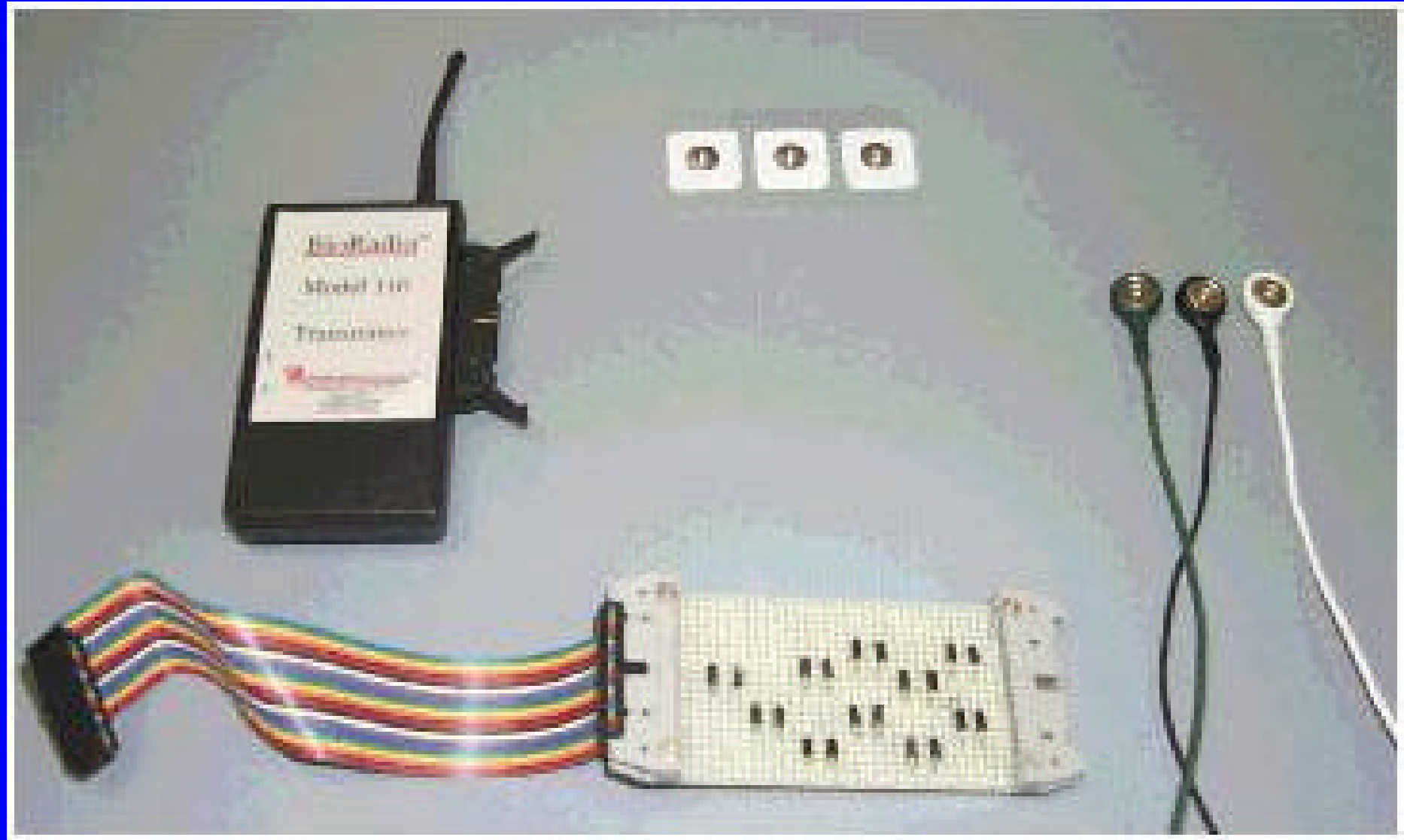
- EEGs - Poststun
- Decapitation

# EEG Pre- and Post-Stun

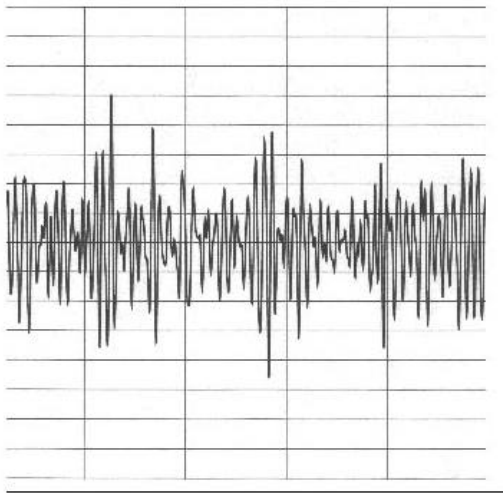
## - Recent developments -

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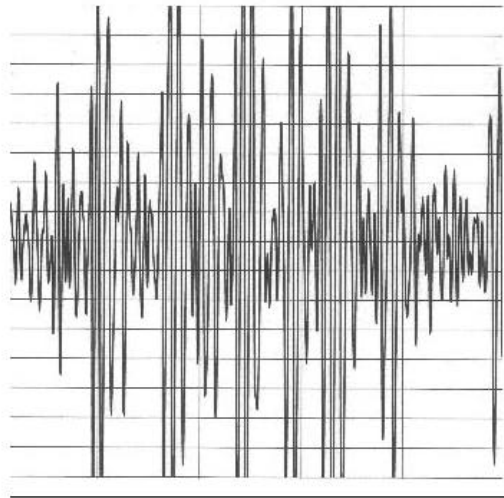
1. Cutaneous snap-on electrodes
  - Requires no surgery or anesthesia
2. Monitor Prestun and Poststun
3. Able to quantify time to death



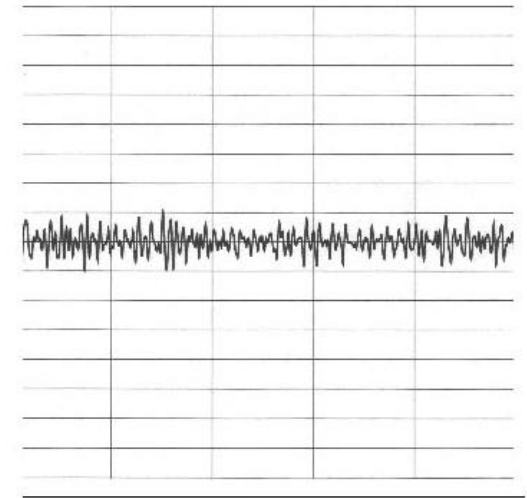
# EEG Characteristic wave forms



10 sec  
**Pre-stun**

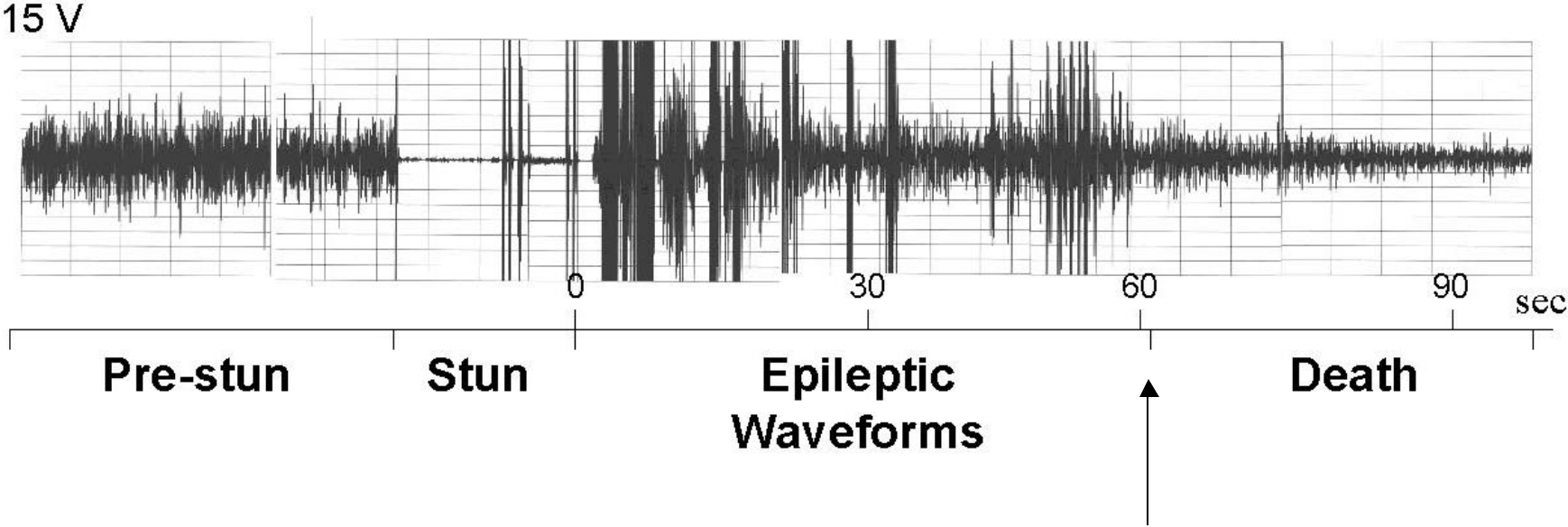


10 sec  
**Epileptic  
Waveforms**



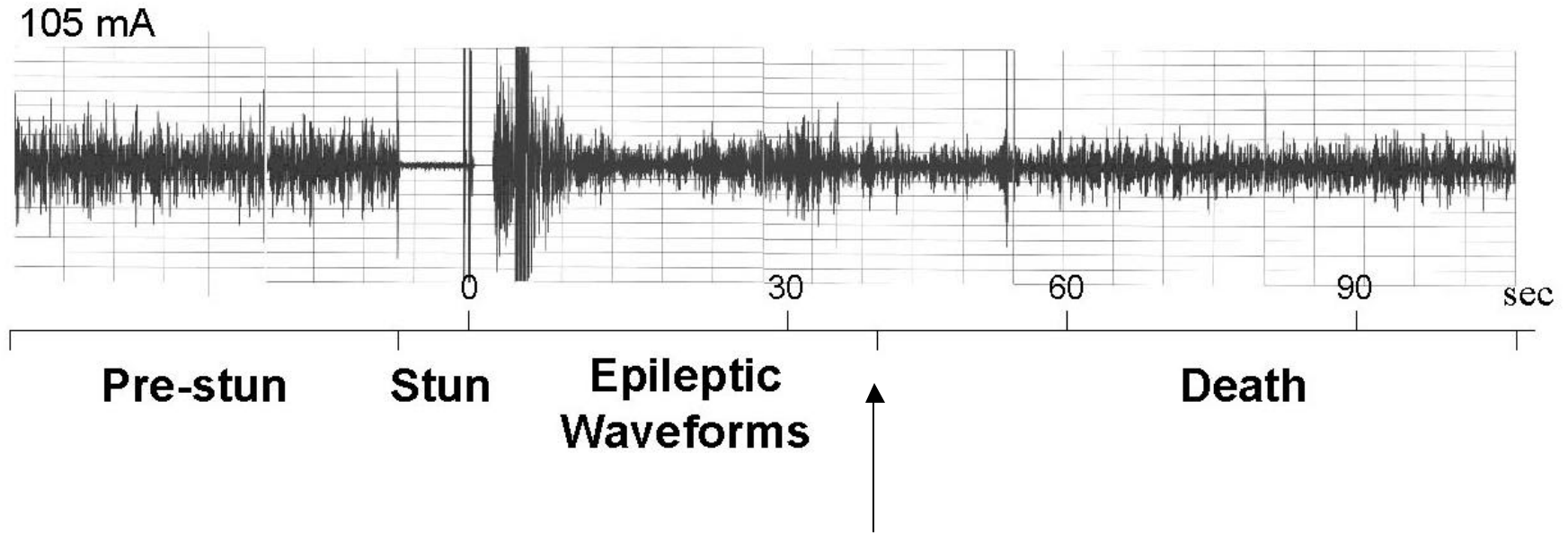
10 sec  
**Death**

# Broiler EEG 15 V ~ US





# Broiler EEG 105 mV ~ EU



# EEGs Post-Stun

## - Future research -

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1. Detection of unconsciousness?
2. Perception of pain stimuli
3. Determine optimum current & voltage for:
  - Unconsciousness
  - Minimal muscular activity
4. Evaluate Gas stunning

# Stunning - Decapitation

## - Recent developments -

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1. Stun – Electric / Gas / Concussion
2. Immediate decapitation

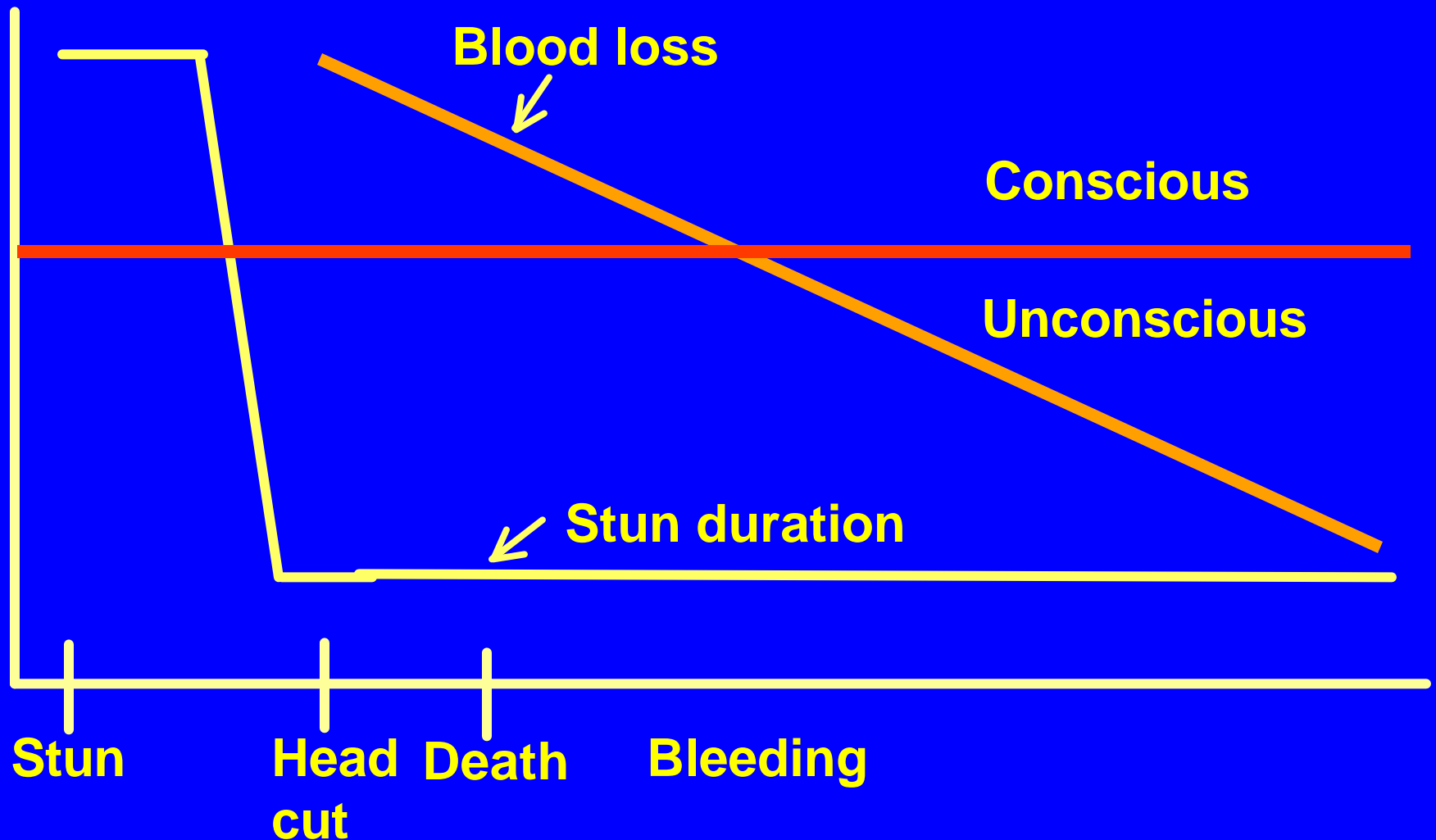
# Stunning - Decapitation

## - Advantages -

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- Instantaneous
- Not possible to regain consciousness
- No muscular or respiratory movements
- Obvious if a bird is missed
- No cadavers

# Stun-Decapitation



# Stunning - Decapitation

## - Advantages -

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- Post decapitation

No longer an Animal Welfare concern

# Stunning - Decapitation

## - Impact -

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- No impact on:
  - Bleed-out blood loss
  - Post-stun muscular activity (less)
  - Defeathering
  - Carcass quality (broken bones)
  - Meat quality (pH, color, yield, shear)

**(McNeal, Fletcher, Buhr 2003)**

# Stunning and Killing

## - Summary -

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- Stunning should be instantaneous
- Stunning should render the animal unconscious until death occurs
- Status of the animal between stunning and killing is ambiguous
- Stunning and killing are integral steps in a single process, not independent operations



# Stunning and Killing

## - Summary -

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- Animal welfare issues may be more associated with system errors than the system itself:
  - Under-stunned
  - Missed or insufficient neck cut
  - Maladjusted equipment

# Summary and Conclusions

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- Stunning technology has advanced greatly over the past 10 years
  - Optimizing parameters for: current, voltage, frequency, duration
- Alternative systems (gas stunning)
  - Has distinct relative advantages and disadvantages
- Expect continued development and advancement in slaughter technology

# **Stunning Systems for Poultry**

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