Physiologic and Metabolic Effects of Traction and Fluid Pumps in Hip Arthroscopy

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Hip Arthroscopy
- Accepted as generally safe procedures with wide range of reported complications (0-27%)
- Most quoted / accepted numbers about 6-7% with .5% major
- Unique features
- Combines vigorous traction with fluid distention using a mechanical pump
- Meta-analysis 2014
  o Gupta et al, J of Arthro and Rel Surg, 30(10):1342-1348
- 285 complications /6160 cases
  o 45% related to traction and/or fluid extravasation

Fluid Pressure Risks
- What metabolic changes can occur because of fluid pressure/flow?
- What are the risks of pump usage?
  o Known and Unknown
- How do we mitigate fluid pressure risks?
- In prolonged exposure > 4 hrs meniscal tissue was more viable in Lactated Ringers Shinjo et al 2002
- But animal studies (Arciero et al) suggest no differences between fluids including water in respect to tissue effects

Metabolic Effects of Pressurized Fluid
- Pressure affects molecular diffusion across the interstitial matrix
- The interstitial matrix:
  o Provides elastic supporting structure
  o Acts as an ion-exchange resin for large quantities of important ions (ie Ca++ and Na+)
  o Exerts profound influence on transcapillary partition and water exchange – fluid reservoir for the cardiovascular system.
- Pressure affects convective flow and osmolarity changing matrix hydration

Inflow ≠ Outflow
- Stafford et al 2011
  o Avg Infused 9.7 L
  o Avg Extravasated 1.1 L
  o Correlated with pressure and duration of surgery
Risks of Pump usage and fluid extravasation

- Cardiac arrest
- Subcutaneous edema and emphysema
- Intra-abdominal Fluid Extravasation (IAFE)
  - Abdominal compartment syndrome
  - Hydroperitoneum
- No reported lower extremity compartment syndromes

Mahorn Group

- 15 Hip Arthroscopists
- 25650 procedures
- 40 cases of IAFE
  - Higher pump pressures (Mean of 69 mmHg vs 55mmHg)
  - 63% association with psoas lengthening
  - Extravasated fluid volume 1.4 L

Warning Signs of Fluid Extravasation

- Increased fluid requirements
- Inability to distend joint
- Frequent cutoff of pump
- Abdominal and thigh distension
- Acute hypothermia

Mitigation of fluid pressure

- Know your PUMP
- Monitor abdomen buttock and thigh for increased swelling tension
- Use lowest appropriate pressure
- Sequence surgery to perform procedures associated with Abdominal extravasation last (i.e. Psoas release)

Physiologic Effects of Traction

- Does Application of traction cause muscle Trauma?
- Neural injury?

Traction Effects

- What metabolic or physiologic effects occur because of traction?
- What are the risks?
  - Transient vs Permanent
- How do we reduce the risks of traction
Traction

- 8 mm
- 50 lbs
- 2 hours
- Telleria et al
  - Force
tcMEPs and SSEPs
- 38.1 kg in patients with injury
- 32.9 kg in patients without
  - Duration of traction did not predict injury
- Martin et al Pilot Study
- 30 patients
  - D- Dimer, CPK-MM
- 15 Patients
  - SSEP
- 15 Patients
  - Duplex US

Mean Traction time 27.3 minutes Mean Traction Force of 57.7 lb

- Duplex ultrasonography
  - 13/15 patients demonstrated > 50% decrease in flow at onset of traction
- SSEP
  - > 50 % Amplitude drop in 8/15 patients with 9/15 having a drop on contralateral limb

Injury Patterns

- Direct Compression from Perineal post
  - Pudendal Nerve
  - Labia
  - Scrotal Hematoma
- Direct Compression Boot
  - Swelling
  - Dorsal foot numbness
- Distraction – Sciatic Nerve SPN and Posterior Tibialis – No permanent sequelae
**Acute lengthening Effects on Nerves**

- Stress/strain is initially non linear
- <10% stretch associated with decreased amplitude but no permanent injury
- (In Rabbit model) > 50% decrease in amplitude
  - Irreversible damage
- Amount of force has been consistently identified as more important than duration of traction (fracture care and hip surgery)

**Traction Mitigation**

- Intermittent usage during case
  - Otherwise consider release after 60-90 minutes
- Optimize vector of force
- Pad extensively
- Optimize work flow
- Keep Patient paralyzed when traction up
  - 300-500 N anesthetized
  - Up to 900 N un-anesthetized
  - Ericksson, 1986
- Air Insufflation
- Dienst, 2002

**Future Directions**

- Pioneering work of Hal Martin needs to be expanded
- Effects on neural elements of fluid pressure particularly in peri-trochanteric space needs to be better understood
- Accurate simple tensionometers
- Improved techniques minimize traction times
References


Bartlett, Craig S.; DiFelice, Gregory S.; Buly, Robert L.; Quinn, Thomas J.; Green, Douglas


