A Long term journey: Managing Complication & SURGICAL REHABILITATION OF UPPER LIMB IN TETRAPLEGIA

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SURGICAL REHABILITATION OF UPPER LIMB IN TETRAPLEGIA

- Need for upper limb rehabilitation
- Early active management
- Patient assessment
- Surgical plan & execution
- Outcome of treatment
- Future trend
WHY is there the need?

- Majority are young adult (Ditunno 1994)
  - between 16-30: 59%
  - Male: 82%

- Initial Survival: 94%
- Normal life expectancy: 88%
Most survivors are of C6 segmental level (EA Zancolli 75%, D Lamb 67%)

75% wish to have upper limb function restored (Hanson & Franklin 1976, Snoek 2001)
THE NATURAL DESIRE
FOR HAND FUNCTION

- Self care
- Work
- Leisure
- Sex
- Independence
- Self-confidence & esteem
- Humanity ........
THE PROBLEMS

- Lack of single hand grip
- Lack of strong grasp
- Lack of rapidity
- Lack of dexterity

.........
“There can be few more catastrophic injuries for a young person at the height of physical powers than an injury of the cervical spine with complete cord damage”
How much can we offer to help these poor patients?
GOAL OF MANAGEMENT OF UPPER LIMB

1. Prevention of complication
2. Correction of deformity
3. Improvement of function
TREATMENT MODALITIES TO IMPROVE FUNCTION

1. Orthosis & Adaptive Devices
2. Surgical Reconstruction
3. Neuroprosthesis
4. Combination of Procedures
ORTHROSIS & ADAPTAIVE DEVICES

Wrist Driven Flexor-hinge Splint
EA Zancolli:

“...It is also very important for them to be able to shake someone’s hand with their own hand rather than an orthosis ….”
DIFFICULTIES IN SURGICAL RECONSTRUCTION

- Multiple problems
- Less predictable recovery
- Poorer general physique
- Low moral
- Dependency on remaining function
FURTHER MORE ...

- Bilaterality
- Limited motor resources
- More difficult surgery?
- Higher dependency
- Greater post-op care
- Loss of existing function (temporary)
PLAN OF SURGICAL RECONSTRUCTION

1. Early active treatment
2. Continuous evaluation
3. Classification of patient
4. Ultimate goal of reconstruction
5. Timing & sequence of operation
6. Rehabilitation
EARLY ACTIVE MANAGEMENT
PATIENT EVALUATION

1. SENSORY
2. MOTOR
3. FUNCTIONAL
4. PSYCHO-SOCIAL
CONTINUOUS PATIENT EVALUATION

- Neurological recovery take at least 1 year
- Little relationship between level of skeletal injury & spinal cord lesion
- Lesion asymmetrical in 50% of cases (RL Waters 1993)
- Unusual pattern of sensory or motor sparing
SENSORY EVALUATION

Erik Moberg 1978:

every useful motor grip is just a response to afferent impulses, coming from cutaneous sensibility, vision or the auditory system

TACTILE GNOSIS

essential for learning motor skill
SENSORY EVALUATION

- Weber 2-points discrimination test
  - 2PD $\leq 10$mm $\Rightarrow$ tactile gnosis +ve

- Vision alone $\Rightarrow$ reconstruction limited to one hand
Motor Recovery Pattern

RL Waters et al Arch Phys Med Rehabil 1993 (n=61)

Lower Limb
- Gr 0/5 at 4/52 ⇒ No recovery in 90%

Upper Limb
- Predict recovery to ≥ Gr 3/5 at 1 year
Rate of Motor Recovery

JF Ditunno et al  Arch Phys Med Rehabil 1992 ( n=150)

.... Gr 1-2 at 1 week
--- Gr 0 at 1 week

Percent of Subjects

Months after Injury
MOTOR EVALUATION

- 3 muscles of central interest:
  1. Deltoid (posterior 1/3)
  2. Brachioradialis
  3. ECRB/ECRL

** Need Gr 4/5 for transfer purpose
Posterior 1/3 Deltoid
Brachioradialis
ECRL / ECRB

Sulcus Sign
Utmost Important to ensure ECRB of Sufficient Strength to avoid Disaster!!
FUNCTIONAL EVALUATION

Objective hand function test & ADL assessment

- Jebsen test, Sollerman test
- Canadian Occupational Performance Measure (Mulcahey JHS 2003)
- Grasp & Release Test
- Functional Independence Measures (FIM)

Video recording
PSYCHO-SOCIAL EVALUATION

- psychological adjustment
- motivation
- cooperation
- expectation
- socio-economic status
- family support
PSYCHOLOGY

- The MAJOR obstacle -

- Delicate mind
- Easily influenced by external inputs & belief system
- Strong faith on future technology
- Belief on Miracle
International Classification for Surgery of the Hand in Tetraplegia

Edinburgh 1978
( modified - Giens, France 1984)
CLASSIFICATION OF PATIENT

- practical classification using spared muscles & sensibility
- guide to transfer in forearm & hand, not for shoulder
- each UL may have different classification
**INTERNATIONAL CLASSIFICATION**

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<tr>
<td>0</td>
<td>No muscle below elbow</td>
</tr>
<tr>
<td>1</td>
<td>BR</td>
</tr>
<tr>
<td>2</td>
<td>+ ECRL</td>
</tr>
<tr>
<td>3</td>
<td>+ ECRB</td>
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<tr>
<td>4</td>
<td>+ PT</td>
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<tr>
<td>5</td>
<td>+ FCR</td>
</tr>
<tr>
<td>6</td>
<td>+ Finger Extensors</td>
</tr>
<tr>
<td>7</td>
<td>+ Thumb Extensor</td>
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<tr>
<td>8</td>
<td>+ Partial Digital Flexors</td>
</tr>
<tr>
<td>9</td>
<td>Lack only Intrinsics</td>
</tr>
<tr>
<td>10</td>
<td>Exceptions</td>
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**SENSIBILITY**

O = Ocular sense

OCu = 2PD ≤10mm
ULTIMATE GOAL OF RECONSTRUCTION

- ACTIVE ELBOW EXTENSION
- SINGLE HAND GRIP
- IMPROVE BOTH HANDS IF POSSIBLE
GENERAL PRINCIPLES

1. Timing of operation
   - at least 1 year?
   - As early as 3 months

2. Resource maximization into 1 or 2 simple functions

3. Minimize no. of operations

4. Never impair existing function

5. Reversibility of surgical procedure
GENERAL PRINCIPLES

6. Always START ON:
   - side with better function
   - side with better sensibility
   - dominant hand first if both are of the same level

7. Create two hands with different functions
GENERAL PRINCIPLES

8. One stage vs two stage key pinch reconstruction & elbow extension procedure
BASIC PROCEDURES

1. ELBOW EXTENSION
   - DELTOID TO TRICEPS TRANSFER
   - BICEPS TO TRICEPS TRANSFER

2. WRIST EXTENSION
   - BRACHIORADIALIS TRANSFER

3. IMPROVE RELEASE
   - PASSIVE ⇒ EXTENSOR TENODESIS
   - ACTIVE ⇒ TENDON TRANSFER
4. IMPROVE GRIP

PASSIVE ⇒ KEY PINCH (TENODESIS)
ACTIVE ⇒ TENDON TRANSFER + INTRINSIC TRANSFER

5. IMPROVE MECHANICAL ADVANTAGE

ARTHRODESIS
TENODESIS
GENERAL SURGICAL STRATEGY
High-level Tetraplegia (Gp 0-2)

- Elbow extension
- Wrist extension
- Tenodesis key pinch
DELTOID TO TRICEPS TRANSFER (MOBERG)

- Purposes:
  - Stabilize patient himself in wheelchair
  - Improve control of self-help devices
  - Improve function of transferred BR
Technical Cue

- Posterior 1/3 (independently innervated)
- Beware of axillary / radial nerve
- Ensure excursion > 3 cm
Fascia Lata Graft
● Direct bone anchorage at olecranon

● Too tight rather than too loose!
Rehabilitation

Long arm cast in 0-10° extension x 4/52

Hinged elbow brace
10-20° ↑ active flexion per week

Passive flexion & strengthening 8-10/52

** Night time extension brace x 4-6 months
Deltoid to Triceps Transfer

The single most useful tendon transfer in tetraplegic patients
M /49  Gp O- 0

- C3-5 # Dislocation 1996
- Rt BEA shoulder 2/5
- Lt Post. Deltoid 4 /5
  Elbow Flex 4+/5
  Ext 0 /5
  BR 3+/5
- Elbow Flexion/Supination Contracture
- Finger Extension Contracture
13.3.2000

Posterior Deltoid to Triceps
BR to Wrist Extensors
MCPJ Capsulectomy
MOBERG KEY PINCH RECONSTRUCTION

Paul Brand modification
Split Distal FPL
Tenodesis (Rothwell 1992)
Mid-Level Tetraplegia (Gp 3-5)

- **Release** - Passive Extensor tenodesis or active transfer
- **Grasp** - Active Flexor transfer
- **Pinch** - 1\textsuperscript{st} CMCJ fusion /opponenplasty
  - Split Distal FPL Tenodesis
- **Anti-Claw** - Intrinsic tenodesis
- **Staged procedures**, Best sequence ??
Extensor Tenodesis
Active Flexor Reconstruction

- BR / PT → FPL
- ECRL → FDP

Supernumerary Extensor
Thumb CMCJ Fusion
Group OCu 7

1st CMC fusion, lasso, 2nd MCPJ dorsal capsulodesis
INTRINSIC TENODESIS

- FDS LASSO Procedure
  (ZANCOLLI 1975)
INTRINSIC TENODESIS

Intrinsic Grafting (HOUSE 1985)
Case Illustration

- M / 40
- RTA Victim
- C5/6 Subluxation with Tetraplegia
- Compound # Rt Forearm & Humerus with compartment syndrome
- Good family support
- No spasticity / Bed Sore
**At 2 years post-injury**

<table>
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<th>LEFT (OCu 5)</th>
<th>RIGHT (OCu 3)</th>
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<tbody>
<tr>
<td>BR</td>
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<tr>
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<td>ECU</td>
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<td>Thumb/Finger Extensor</td>
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- 3+ Static Claw Hand Deformity
- * Flexor contracture
Operations

**LEFT**
- ECRL $\rightarrow$ FDP
- BR $\rightarrow$ FPL
- ECU $\rightarrow$ PL graft $\rightarrow$
  Opponen
- FDS Lasso $\rightarrow$ Intrinsic

**RIGHT**
- ECRL $\rightarrow$ FDP
- BR $\rightarrow$ FPL
- FDS Lasso $\rightarrow$ Intrinsic
- MPJ Capsulectomy
- Flexor Release
- Thumb IPJ Stabilization (K Wire)
- $1^{st}$ CMCJ & $2^{nd}$ MCPJ fusion in 2001
8 years PO
Ankylosing Spondylitis

Left: OCu 5
Right: OCu 4
5 years PO
Low-level Tetraplegia (Gp 6-9)

- Simulate Median / Ulnar Nerve Palsy
- Active Flexor Re却construction
- Intrinsic Control
OUTCOME OF SURGICAL RECONSTRUCTION
1996-2006

- Case registry : 56
- M:F = 49 : 7
- Av Age : 40.1 (17-67)
- Median interval from injury : 11 months
  (10 days to 204 months)
- Surgical candidate : 40 (71.4%)
- Operated case : 12 (30%)
NEUROPROSTHESIS
(FUNCTIONAL ELECTRICAL STIMULATION)

mainly to restore grasp & release for C5 & C6 level injury
Surgically implanted device

- 8 channels of stimulation
- Programmable to synchronise movement
- Shoulder / wrist control
FUTURE PROSPECT

COMPENSATE FOR DEMYELINATION
- Supply chemicals that prevent nerve impulses from dissipating at demyelinated areas
- Provide agents that spur surviving oligodendrocytes to remyelinate axons
- Replenish lost oligodendrocytes (see “Replace Dead Cells” box on next page)

PROMOTE AXONAL REGENERATION
- Deliver agents that overcome natural inhibitors of regeneration
- Administer compounds that induce axonal regrowth

DIRECT AXONS TO PROPER TARGETS
- Somehow supply needed guidance molecules at the right sites
- Administer compounds that induce surviving cells to produce or display guidance molecules

PREVENT EXPANSION OF INITIAL DAMAGE
- Deliver agents that block so-called excitotoxic injury to surviving cells
- Administer compounds that prevent cell suicide or that otherwise bolster the defenses of stressed cells

CREATE BRIDGES
- Implant (into cyst) tissue that can serve as a scaffolding for axons and encourage them to grow

REPLACE DEAD CELLS
- Implant cells able to produce all the lost cell types
- Deliver substances that can induce undifferentiated cells already in the cord to replace dead cells
FUTURE PROSPECT

Spinal Cord Repair

Olfactory Ensheathing Cell

because it means inconvenience with no immediate visible advantage.
Young hopes that attitude will change.
"In China no one would sign up for placebo treatment," he says.
"Participating in a clinical trial is a service to your community that
requires a degree of sacrifice. If they just get the therapy and disappear
then there's no data."

Huang dreams of setting up an international centre in Beijing
offering his operation to people from around the world. They are arriving
already. Despite a six-month waiting list the team tries to limit the
number of patients on the ward to four owing to a lack of staff. Throwing
his arms wide, Huang says: "We are open to the whole world."

But again Huang stresses his treatment is no cure. "This is a very
important point. It's not a cure," he reiterates. "I say: 'I never promised
you would walk after my procedure. You can improve. But you won't be
healed.' Expectations shouldn't be too high. What's important is that it
has proved the old way of thinking is wrong. In three years we won't have
the cure but we may have new methods."

The website of the Christopher and Dana Reeve Paralysis Resource
Centre echoes Huang's optimism and caution. Asking "Is there hope for
a cure?" it answers by saying: "If by 'cure' you mean full return to the
way a person was before injury or disease, that may be asking more than
the research can deliver for now."

While acknowledging the results so far, Young puts it more bluntly:
"Nobody's getting out of bed and running a marathon," he says.
What do I learn from them?
CONCLUSION

What we can do now is only a little

BUT…..

“ IF YOU HAVE NOTHING, A LITTLE IS A LOT ! ”

Sterling Bunnell
THANK YOU