Peri-operative Care for Pressure Ulcer Surgery
Optimizing for Successful Outcomes
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No commercial support was received for this activity.

Walter C. Chua, MD, FAPWCA has no financial interest or relationships to disclose.

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Learning Objectives

At the conclusion of this activity, the participant will be able to:

1. Discuss the pre-operative evaluation of candidates for surgical repair of pressure ulcers

2. Formulate a post-operative care plan after the surgical repair of pressure ulcers

3. Describe strategies to prevent recurrence of pressure ulcers after surgical repair
Introduction

- Pressure Ulcers are a major complication of SCI/D
- Will develop in ≥50% of veterans with SCI/D
- Overall prevalence of 39%
- Almost half of these pressure ulcers are Stage IV (NPUAP)
- Ischia most common anatomic site

Introduction

- Multiple ulcers found in 70% of patients
- Average treatment cost per patient ~$70,000 (1992)
- Surgical consult for repair requested in 67% of cases
- Recurrence rate is significant (~40%)
- Mean time to recurrence is about 4 months

Management Goals

- Prevention of Complications
- Prevention of Further Tissue Loss
- Prevention of Ulcerations at Other Anatomic Sites
- Wound Closure (surgical or non-surgical)
- Palliation (if closure not possible)
Pressure Ulcer

Infection Control
Correction of Ischemia
Nutritional repletion
Correction of Hyperglycemia
Pressure Relief (Offloading)

Surgical Candidate?

Flap Closure

Wound Bed Preparation (DIME)

Weekly Wound Assessment
Measurements
Photography
Validated Tool (e.g. BWAT, PUSH, SCI-PUMT)

Has Wound Healed ≥50% in 4 weeks?

Advanced Wound Care
Biophysical Modalities
Growth Factors
ECM Products
Bioengineered Skin Substitutes

YES

NO
Ulcer Pathophysiology

- Pressure ulcers maintain a chronic inflammatory state
- Prolonged inflammation alters tissue biology:
  1. Fibroblasts become senescent quicker
  2. Expression of adhesion molecules reduced
  3. Cell-cell interaction impaired
  4. Extracellular matrix proteins abnormal/lacking

Ulcer Pathophysiology

- Chronic inflammation inhibits healing
- Surgical intervention interrupts inflammatory cycle
- Patient with ulcers tend to have anemia, low serum iron, increased ferritin, reduced transferrin & transferrin saturation, increased ESR & CRP, reduced albumin, total hypoproteinemia
- All these parameters normalize after flap surgery

Goals of Surgical Repair

1. Restoration of skin integrity and homeostasis
2. Diagnosis & Treatment of osteomyelitis
3. Prevention of subsequent pressure ulcers?
Restoration of Skin Integrity

Ulcers have an absolute tissue deficiency

Flaps bring in tissue with predictable blood supply

Musculocutaneous or Fasciocutaneous flaps most common

All dead space should be obliterated by flap (and drained)

Flaps should be inset with minimal tension

Cutaneous Vascular Supply

Adapted from Patel KG, Sykes JM. Oper Tech Otolaryngol 2011;22(1):13-23.
Cutaneous Vascular Supply

Adapted from Krishnan, 2008.
Flap Anatomy

Fasciocutaneous Flap

Musculocutaneous Flap

Adapted from Patel KG, Sykes JM. Oper Tech Otolaryngol 2011;22(1):13-23.
Flap Type

- Musculocutaneous flaps have significant bulk, excellent blood supply but are susceptible to ischemia injury and loss of muscle function and stability.

- Fasciocutaneous flaps maintain good blood supply, are less susceptible to ischemia, but limited in depth and bulk.

Fasciocutaneous Flap

Adapted from Krishnan, 2008.
Musculocutaneous Flap

Adapted from Krishnan, 2008.
Diagnosis/Treatment of Osteomyelitis

Radiologic studies are far from definitive

Pre-operative imaging is of limited benefit

Diagnosis based on histology and culture of O.R. specimen

Treatment in O.R. requires removal of all diseased bone

Antibiotics chosen to cover bacteria isolated in O.R.

Antibiotics given for 4-6 weeks

Prevention of Future Ulcers?

Ulcerc recurrence after surgery is multi-factorial

Surgical intervention can only alter local anatomy

Anatomy changed to improve pressure re-distribution

1. Scar tissue excised
2. Bony prominences de-bulked and flattened
3. Supple well-vascularized tissue brought to cover bone

Who is a surgical candidate?

Surgical closure of pressure ulcers is elective/semi-elective

Should not be considered when ulcer is getting worse, but rather when ulcer is improving as this shows that there is healing capacity.

Who is a surgical candidate?

Risks versus Benefits:
Do benefits outweigh risk of complications?

Costs versus Benefits:
Will ulcer-free time justify time/resource commitment?
Surgical Planning
Strategies for Success

1. Patient Selection
2. Procedure Selection
3. Appropriate Post-operative Care
4. Post-discharge Follow-up (Recurrence Prevention)
Patient Selection

1. Medically stable
2. Adequate nutrition
3. Nicotine-free for at least 4 weeks
4. Able (and willing) to perform pressure relief maneuvers
5. Appropriate management of fecal/urinary soilage
6. Control of spasms
7. No history of noncompliance
Nutrition

- Albumin ≥ 2.0
- Pre-albumin normal/rising over 3 weeks
- Correct deficiencies of vitamins A, C; Zn, Ca, Fe, Cu
- There is NO evidence that megadoses are of benefit
Smoking

Smoking impairs wound healing by:
1. Vasoconstriction
2. Displacement of $O_2$ binding by CO
3. Increased platelet aggregation
4. Impairment of inflammatory cell oxidative burst
5. Reduced collagen deposition
6. Endothelial damage
7. Development of atherosclerosis
8. Increases blood viscosity

Smoking

- Pre-operative smoking abstinence >3 weeks reduced incidence of impaired wound healing in reconstructive head & neck surgery.

- Smoking cessation 6-8 weeks before surgery reduced wound-related complications after hip and knee replacement surgery from 31% to 5%.

- Smoking one pack/day leads to flap necrosis three times more frequently; two packs/day six times more frequently.

Smoking

• One cigarette can cause vasoconstriction for 90 minutes

• One cigarette can reduce blood flow in skin by 42%

• After smoking for 10 minutes, skin PO$_2$ is reduced by 22-48% after 30 minutes, to a mean PO$_2$ of 44±3mm Hg

Sarin CL et al. JAMA 1974;229:1327-1328.
Smoking

Monitoring Nicotine Use

- Nicotine half-life about 2 hours
- Metabolized by liver
- Major metabolite is cotinine
- Cotinine half-life about 20 hours
Control of Fecal/Urinary Soilage

- Healing of incisions impaired by fecal/urine exposure
- Consider colostomy for ulcers close to anus
- Stoma construction has low morbidity and mortality
- Colostomy helps heal ulcers and decreases recurrence
- Colostomy simplifies personal hygiene, decreases bowel care time

Control of Fecal/Urinary Soilage

- Urinary incontinence/pelvis moisture is a major risk factor for the development of pressure ulcers in SCI
- Definitive intervention usually by suprapubic cystostomy or incontinent urinary diversion such as ileal conduit
- Continent urinary diversion preferred management in motivated patient

Control of Spasms/Contractures

- Spasms can damage soft tissue through shear forces, can rip open fresh incisions
- Valium, baclofen, dantrolene, nerve block, epidural stimulators, baclofen pumps, rhizotomy, botox, epidural block
- Contractures can limit positioning
- Treat with therapy, tendon release/division

Non-compliance

• “Patients believed to be candidates for complete post-operative rehabilitation are offered surgical repair. Individuals who cannot cooperate with protocol are treated non-operatively.”

• “Experienced clinicians will consider the patient’s socioeconomic conditions heavily when deciding on course of management.”

• Subjective screening:
  • Ability to adhere to pressure-relief protocols
  • Ability to maintain nutritional health
  • Ability to comply with dressing routines
  • Ability to participate in management of co-morbid conditions

Surgical Technique

1. Proper positioning on O.R. table
2. Peri-operative antibiotics
3. Complete ulcer excision including any bursas or heterotopic ossification
4. Bone biopsy/culture
5. Debulk & flatten bony prominences
6. Myocutaneous and/or fasciocutaneous flaps
7. Cover exposed bone with muscle/fascia

Tension-free Positioning

Prone Jackknife (Kraske) Position for Ischial Ulcer Repair
Post-op Care

- Antibiotics
- Pressure relief off of healing flap and incisions
- Loading after adequate degree of healing
- Wheelchair/cushion evaluation
- Gradual sitting protocol

Air-Fluidized Surface
Fluid Immersion Simulation
Support Surfaces

Pressure defined as force applied per unit area

\[
\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\text{Mass} \times \text{Gravity}}{\text{Area}}
\]

Pressure minimized by immersion and envelopment

Immersion = depth of penetration into a support surface

Envelopment = ability of support surface to conform
Support Surfaces
## Post-operative Mobilization

<table>
<thead>
<tr>
<th>Study</th>
<th>Bed Immobilization</th>
<th>Passive ROM</th>
<th>Sitting</th>
<th>Sitting Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foster et al (1997) UCSF</td>
<td>10-14 days</td>
<td>unspecified</td>
<td>after 2 weeks</td>
<td>unspecified</td>
</tr>
<tr>
<td>Keys et al (2010) VA Puget Sound</td>
<td>5 weeks</td>
<td>after 4 weeks</td>
<td>after 6 weeks</td>
<td>unspecified</td>
</tr>
<tr>
<td>Kierny et al (1998) University of Washington</td>
<td>2-3 weeks</td>
<td>unspecified</td>
<td>after 2-3 weeks</td>
<td>unspecified 7- to 10-day regimen advanced until 4 hrs TID</td>
</tr>
<tr>
<td>Rubayi et al (1999) Rancho Los Amigos</td>
<td>4 weeks</td>
<td>after 4 weeks</td>
<td>after 6 weeks</td>
<td>start at 30 min daily advance by 30 min/day until 6 hrs</td>
</tr>
<tr>
<td>Stal et al (1983) Baylor College/TIRR</td>
<td>4 weeks (prone)</td>
<td>after 5 weeks</td>
<td>after 6 weeks</td>
<td>start at 30 min BID advance by 15 min BID until 4 hrs</td>
</tr>
<tr>
<td>Tchanque-Fossuo et al (2011) University of Michigan</td>
<td>3 weeks</td>
<td>unspecified</td>
<td>after 3 weeks</td>
<td>start at 30 min advance by 30 min daily</td>
</tr>
</tbody>
</table>
Dermal Healing

Vascular Healing of Flaps

After 10-24 hours - Decreased arterial supply; congestion and edema; dilation of arterioles and capillaries

After 1-3 days - Increased number and quality of anastomoses between flap and recipient bed; increased number of small vessels in pedicle

After 3-7 days - Reorientation of vessels along the long axis of the flap; anastomoses created at 1-3 days now functionally significant

After 1 week - Circulation well established between flap and recipient bed

After 2 weeks - Continuous maturation of anastomoses

After 3 weeks - Flap achieves 90% of its final circulation

After 4 weeks - Vessels at definitive size; few remaining newly formed vessels
Graduated Sitting Protocol
VA Long Beach SCI/D

- Bed immobilization for 4 weeks
- Stitches removed at 3 weeks & passive ROM of hip started
- Wheelchair sitting started at one hour at 4 weeks post-op
- Pressure redistributing seat cushion evaluated
- Time advanced by one hour each week as tolerated
- Considered for discharge after tolerating four hours sitting
Arguments Against Flap Surgery

1. High post-operative complication rate (Risk vs. Benefit)
2. High ulcer recurrence at operative site (Cost vs. Benefit)
3. Difficulty obtaining plastic surgery consult
4. Lack of O.R. time for surgery
# Post-operative Complications

<table>
<thead>
<tr>
<th>Study</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Srivastava <em>et al</em> (2009)</td>
<td>17%</td>
</tr>
<tr>
<td>Goodman <em>et al</em> (1999)</td>
<td>40%</td>
</tr>
<tr>
<td>Tavakoli <em>et al</em> (1999)</td>
<td>62%</td>
</tr>
<tr>
<td>Aggarwal <em>et al</em> (1996)</td>
<td>11%</td>
</tr>
<tr>
<td>Sørensen <em>et al</em> (1994)</td>
<td>13%</td>
</tr>
<tr>
<td>Disa <em>et al</em> (1992)</td>
<td>31%</td>
</tr>
<tr>
<td>Mandrekas and Mastorakos (1992)</td>
<td>7%</td>
</tr>
<tr>
<td>Relander and Palmer (1988)</td>
<td>18%</td>
</tr>
<tr>
<td>Løntoft and Kjeldsen (1986)</td>
<td>35%</td>
</tr>
<tr>
<td>Pers <em>et al</em> (1986)</td>
<td>38%</td>
</tr>
<tr>
<td>Kirkby and Holck (1982)</td>
<td>13%</td>
</tr>
</tbody>
</table>

Average = 24%
# Post-operative Complications

VA Long Beach SCI/D 2004-2006

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>N = 189</strong></td>
<td></td>
</tr>
<tr>
<td>Minor Complications:</td>
<td>19%</td>
</tr>
<tr>
<td>Major Complications:</td>
<td>15%</td>
</tr>
<tr>
<td>Wound Infection:</td>
<td>1%</td>
</tr>
<tr>
<td>Dehiscence:</td>
<td>8%</td>
</tr>
<tr>
<td>Tissue Loss:</td>
<td>2%</td>
</tr>
<tr>
<td>Hematoma:</td>
<td>2%</td>
</tr>
<tr>
<td>Seroma:</td>
<td>1%</td>
</tr>
<tr>
<td>MI:</td>
<td>1%</td>
</tr>
<tr>
<td>Death:</td>
<td>0%</td>
</tr>
</tbody>
</table>
Post-operative Complications

VA Long Beach SCI/D 2004-2006
Specific Complications
VA Long Beach SCI/D 2004-2006

- Wound Infection
- Dehiscence
- Tissue Loss
- Hematoma
- Seroma
- MI
- Death

Graph showing the specific complications from 2000 to 2007, with variations in percentage over the years. The highest percentage is observed for Wound Infection in 2003, followed by Dehiscence in 2004.
### Post-operative Recurrence Rates

<table>
<thead>
<tr>
<th>Study</th>
<th>Recurrence Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Srivastava <em>et al</em> (2009)</td>
<td>17%</td>
</tr>
<tr>
<td>Bilkay <em>et al</em> (2006)</td>
<td>22%</td>
</tr>
<tr>
<td>Schryvers <em>et al</em> (2000)</td>
<td>54%</td>
</tr>
<tr>
<td>Goodman <em>et al</em> (1999)</td>
<td>79%</td>
</tr>
<tr>
<td>Tavakoli <em>et al</em> (1999)</td>
<td>48%</td>
</tr>
<tr>
<td>Kierney <em>et al</em> (1998)</td>
<td>23%</td>
</tr>
<tr>
<td>Aggarwal <em>et al</em> (1996)</td>
<td>11%</td>
</tr>
<tr>
<td>Evans <em>et al</em> (1994)</td>
<td>82%</td>
</tr>
<tr>
<td>Sørensen <em>et al</em> (1994)</td>
<td>40%</td>
</tr>
<tr>
<td>Disa <em>et al</em> (1992)</td>
<td>61%</td>
</tr>
<tr>
<td>Mandrekas and Mastorakos (1992)</td>
<td>13%</td>
</tr>
<tr>
<td>Relander and Palmer (1988)</td>
<td>56%</td>
</tr>
<tr>
<td>Løntoft and Kjeldsen (1986)</td>
<td>41%</td>
</tr>
<tr>
<td>Pers <em>et al</em> (1986)</td>
<td>16%</td>
</tr>
<tr>
<td>Kirkby and Holck (1982)</td>
<td>25%</td>
</tr>
<tr>
<td>Berry (1980)</td>
<td>47%</td>
</tr>
</tbody>
</table>

Average = 39%
Repairs without Recurrence
VA Long Beach SCI/D 2004-2006

Days

50%  60%  70%  80%  90%  100%

0  90  180  270  365  450  540  630  730  1095

106%  81%  75%  69%  69%  72%  71%  73%  74%  76%
Recurrent Ulcers by Stage

VA Long Beach SCI/D 2004-2006

Days Post-op

Stage II
Stage III
Stage IV

Days Post-op

90 180 270 365 450 540 630 730 1095
Post-Surgical Recurrence

- Most recurrences occurred within 4 months of discharge
- Recurrence rate equivalent for patients treated surgically or non-surgically.
- Post-discharge follow-up for at least 4 months paramount to prevent/monitor for ulcer recurrence

Post-Surgical Recurrence

1. Lack of compliance
2. Smoking/Drug Abuse
3. Poor control of diabetes (HbA1c>6%)
4. Ischial Location
5. Any previous same-site failure
6. Psychosocial behavior
7. Skeletal abnormality of spine/pelvis
8. Quality and reserve of local skin and muscle
Early vs. Late Recurrence

• “Early” defined as within one year of surgery

• Early recurrence risk factors:
  1. Albumin < 3.5 g/dL
  2. Age < 45 years
  3. Previous same-site failure

• Late recurrence risk factors:
  1. Ischial location
  2. Previous same-site failure
  3. Age < 45

Preventing Ischial Recurrence

Which pressure relief maneuver is most effective?

How long must the pressure relief maneuver be performed?
Ischial Pressure Relief

- Traditional relief lift of 15-30 seconds every 20 minutes
- Mean time of pressure relief to raise TcpO$_2$ (skin oxygen level) to unloaded levels is 111 seconds
- More effective: forward lean, side-to-side shifting, tiltbacks (at least 65°)

Ischial Pressure Relief

- High ulcer risk at TcpO₂ < 30-44 mmHg
- Uncompressed tissue TcpO₂ 80 mmHg
- Average perfusion deterioration time = 200 seconds
- Average perfusion recovery time = 200-250 seconds
- Average sustained wheelchair pushup = 49 seconds

Behavioral Intervention

- Non-adherence most likely occurs with daily long-term complex self-care behaviors with little or no observed relation to eventual outcome.
- Non-adherence for even brief time may result in secondary complications which can perpetuate belief that outcome not related to individual behavior.
- Individuals typically make healthcare decisions based on their unique life situation and personal issues.

Shanmugham K et al. NeuroRehabilitation 2004;19(3):259-269.
Behavioral Intervention

- Followed 9 paraplegics as outpatients with history of hospital admissions for ulcers
- Double-pronged study pairing education with self-care plan and nursing visits and monetary rewards for successfully preventing pressure ulcers
- When patients received payments with nursing visits, ulcer severity was reduced
- For some patients there is insufficient positive reinforcement

Summary

- Early surgical intervention should be considered in all patients with SCI/D with pressure ulcers.
- Proper patient selection is important in reducing operative complications and ulcer recurrence and maximizing surgical success.
- Post-operative protocols are designed to promote functional healing of skin to withstand loading.
- Post-surgical care does not end at discharge, requiring close follow-up.
References


References


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