Forecasting the Future

Predicting Pressure Injury in SCI and TBI Patients

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October 2021

Objectives

- Review Pressure Ulcer Identification
- Review Current Scoring Methods
- Advances in Predictive Modeling
- Interventions for prevention and protection

What's your number-one
day-to-day living problem?
CHRISTOPHER
Injured in 1980 at age 16, Quadriplegic

8%

PU 1st yr after SCI at home

39%

Incidence of PU in 1st 3 yrs. After SCI

50%-80%

SCI- PU lifetime

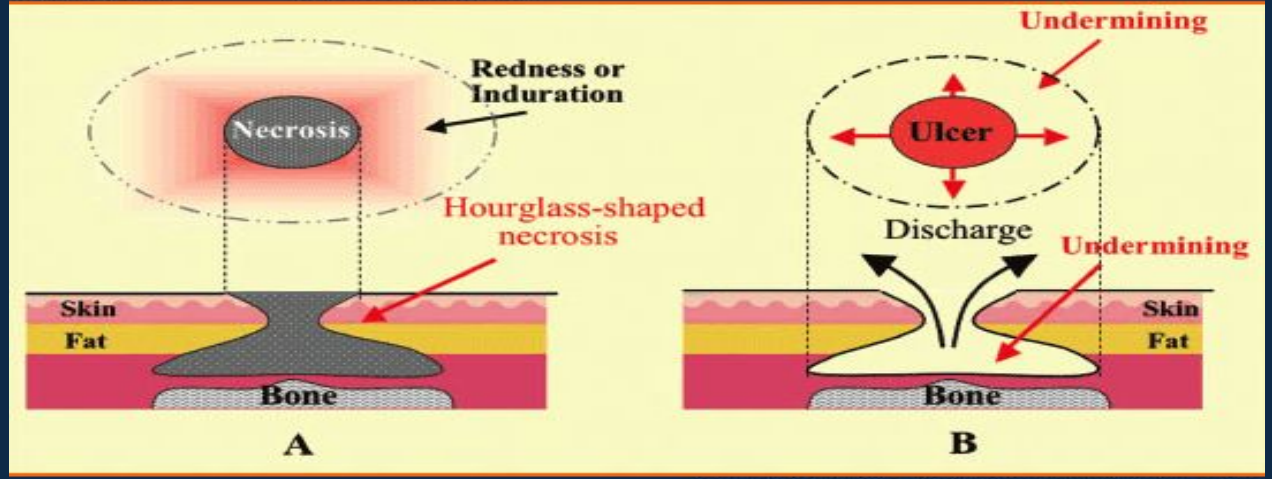
Definition of Pressure Ulcer

- An area of unrelieved pressure over a defined area, usually over a bony prominence such as the sacrum
- Pressure leads to ischemia, cell death, and tissue necrosis, as capillaries are compressed and the blood flow is restricted
- Muscle is the most sensitive tissue to pressure, skin is the most resistant

Most common pressure ulcer sites

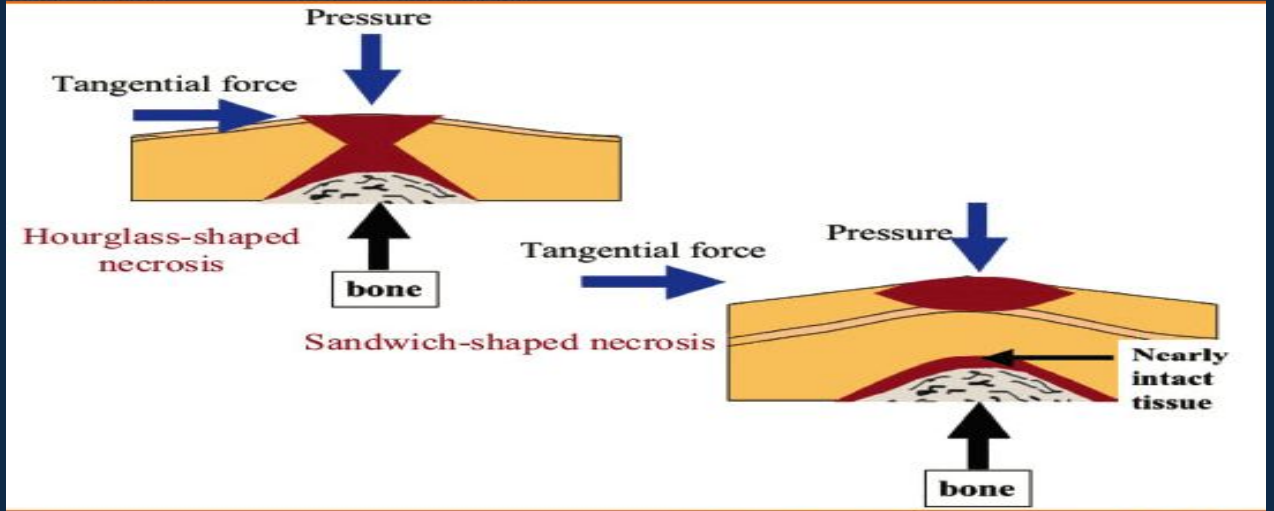
- Ischium 28%
- Sacrum 17-27%
- Trochanter 12-19% (Bears weight when patient is in a sitting position)

- Other commonly affected sites include coccyx, heel, and malleolus



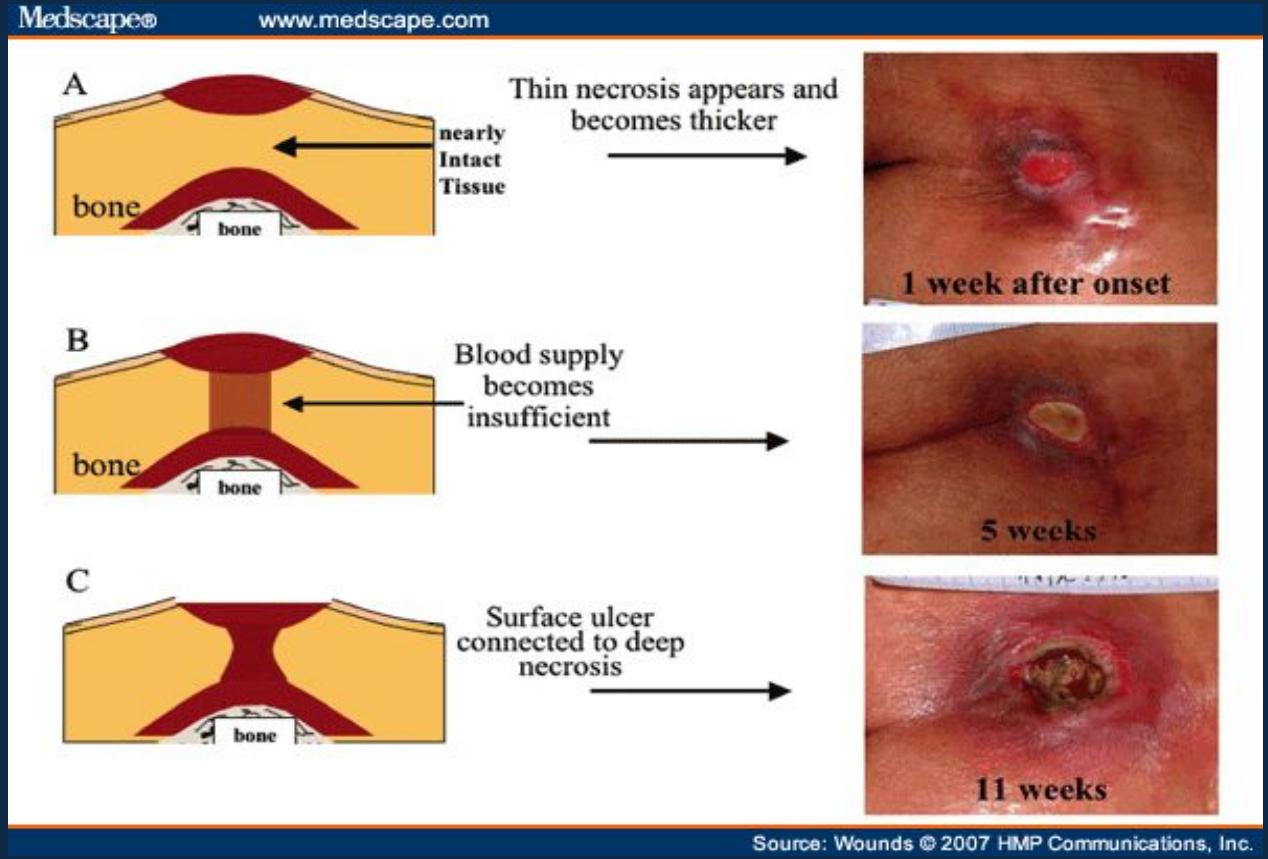
Source: Wounds © 2007 HMP Communications, Inc.

Medscape® www.medscape.com



Source: Wounds © 2007 HMP Communications, Inc.

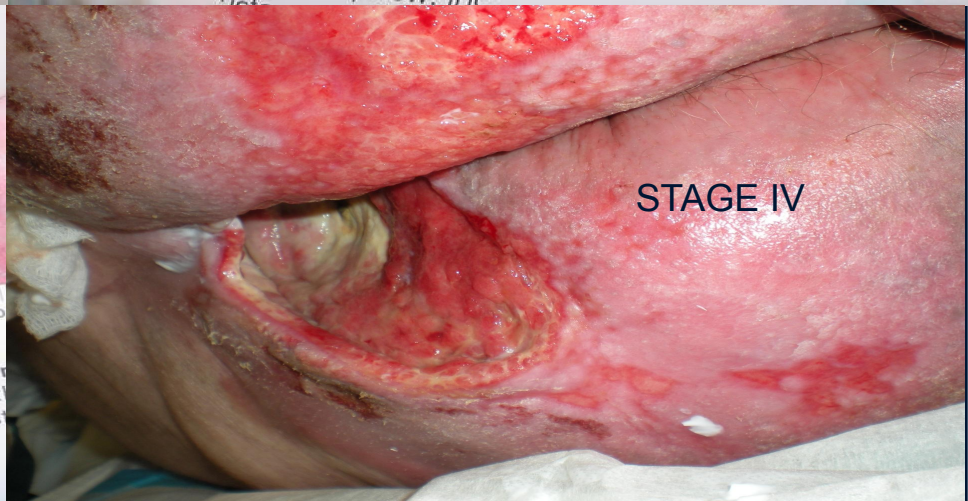
HOUR GLASS NECROSIS



STAGE I
2005 10 17

STAGE II
Wound Management
Smith & Nephew, Inc
2004 12 27

STAGE III
2005 3 17


STAGE IV

UNSTAGEABLE

DTI

060Y
11/15/1944
4/7/05

Assessing Dark Skin

- Have a high index of suspicion
- Use good lighting
- Compare Skin Color to surrounding area
- Enhance Visual Assessment by moistening skin (sebum vs Ceramide)
- Superficial are easily identified
- Palpate skin for edema
- Variation - Stg 1 (32%) vs DTI(67/8%) –African American
- Perfusion/Thermography
- Healing changes pigmentation

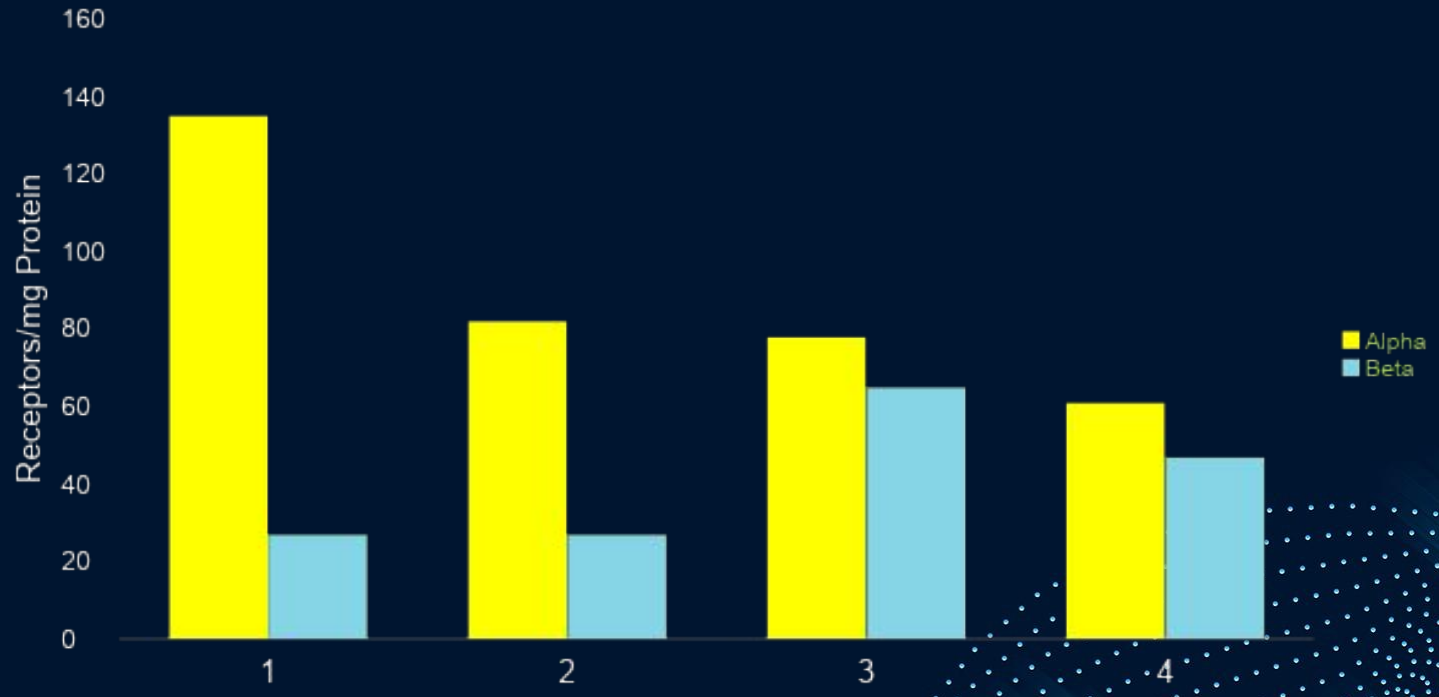
Ten top tips: assessing darkly pigmented skin
Wounds International 2020 | Vol 11 Issue 3 , Black et al

TIMING IS EVERYTHING

- The median time to pressure ulcer occurrence was 5 hours at mild or moderate risk
- 3.5 hours at high risk
- 3 hours at very high risk on the Braden scale
- The optimal time interval for position change was 3 hours at mild and moderate risk, 2 hours at high and very high risk of Braden scale.

J Korean Acad Nurs 2012 Oct;42(5):730-7.

Adrenergic Receptors in Insensitive Skin of Spinal Cord Injured Patients



Gladys et al Arch Phys Med Rehab Vol 67 March 1986

Nutritional Parameters in TBI/NTBI

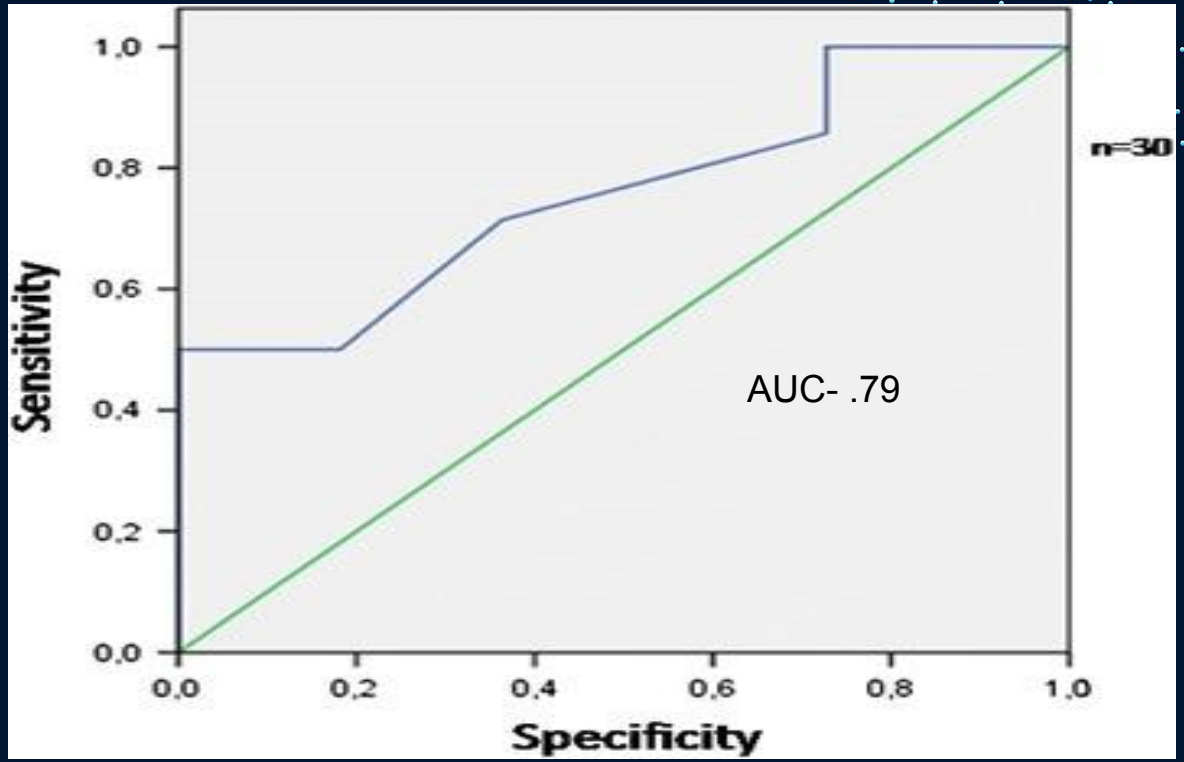
Italian study with 30 pts admitted in a neuro rehab institute
age 45-76 , 16 male, 14 female, 8 TBI, 11 ischemic CVA, and 11 with anoxic brain injury

Parameters:

- age
- BMI
- Mid Arm Circumference (MAC)
- TBW
- Energy exp, Caloric intake,
- Hgb
- Iron, Albumin
- WBC
- CA
- Cr
- Glucose
- Age, Disease duration

Nutritional Parameters Predicting Pressure Ulcers and Short-Term Disability with minimal conscious state as a result of TBI and NTBI Montalcini et al, Journal of Translational Medicine 2015

AUC for Albumin to Predict Pressure Ulcers in TBI and NTBI



Nutritional Parameters Predicting Pressure Ulcers and Short-Term Disability with minimal conscious state as a resulti of TBI and NTBI Montalcini et al, Journal of Translational Medicine 2015

COMMON TOOLS IN PU RISK ASSESSMENT FO SCI/TBI

- **Braden**: Moisture, mobility, nutrition, friction/shear , activity, sensory perception
- **Scipus-** activity, mobility, level of spine injury, moisture/incontinence, hosp versus snf, nutrition other factors, (such as age, tobacco use/smoking, pulmonary disease, cardiac disease abnormal blood glucose control, renal disease, and impaired cognitive function)
- **Scipus A** (acute hosp)- extent of paralysis, incontinence, nutrition, pre-existing disease (pulm), mobility, level of activity
- **Norton** - activity, mobility, incontinence, physical condition, and mental condition.

ORIGINAL BERGSTORM/BRADEN STUDY

- 100% sensitive in 2 studies of N=100 for scores 16-23
- Steep drop of sensitivity at scores 15 or below
- Predominantly Caucasian elderly male
- Mostly CVA and orthopedic surgeries
- AAJC 2013 study 7790 ICU – Sensitivity of 95% and specificity of 20% . There is a low PPV in ICU .114 and NPV of .977
- 2016 Meta-analysis of 41,450 pts and 1058 PU showed sensitivity of 89% and specificity of 28% with an AUC of .78

BRADEN SCALE

Sensory	Complete	Limited	Slight	None	4
Moisture	Constant	Very	Slight	Rare	4
Activity	Bed	Chair	Walks some	Walks a lot	4
Mobility	Immobile	Very Limited	Slightly Limited	No Limits	4
Nutrition	Very Poor	Rarely	Adequate	Good	4
Friction	Problem	Potential	None		3

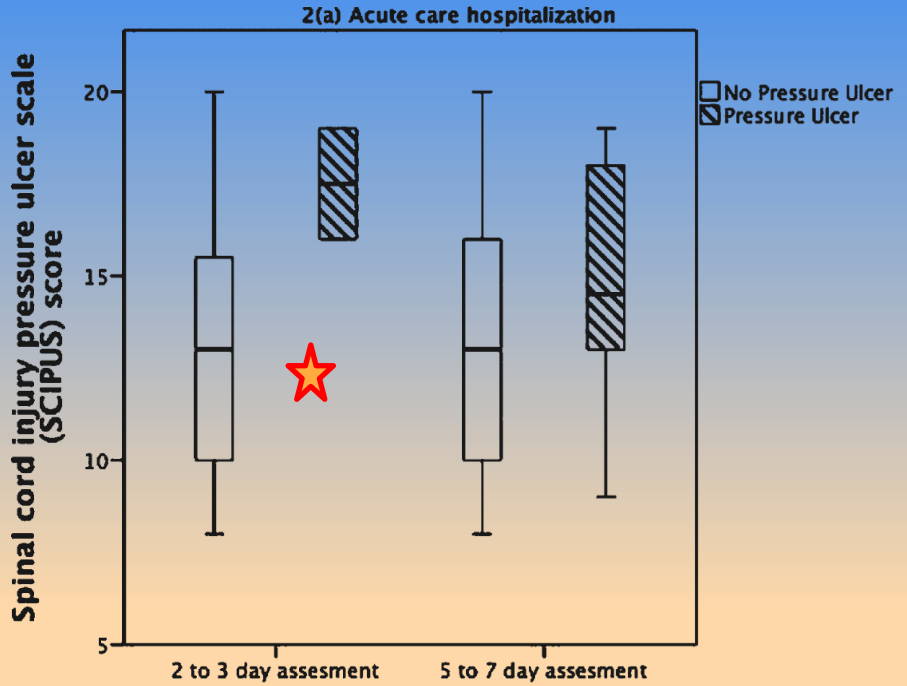
The Braden Scale for Predicting Pressure Sore Risk- July 1987 Nursing Research

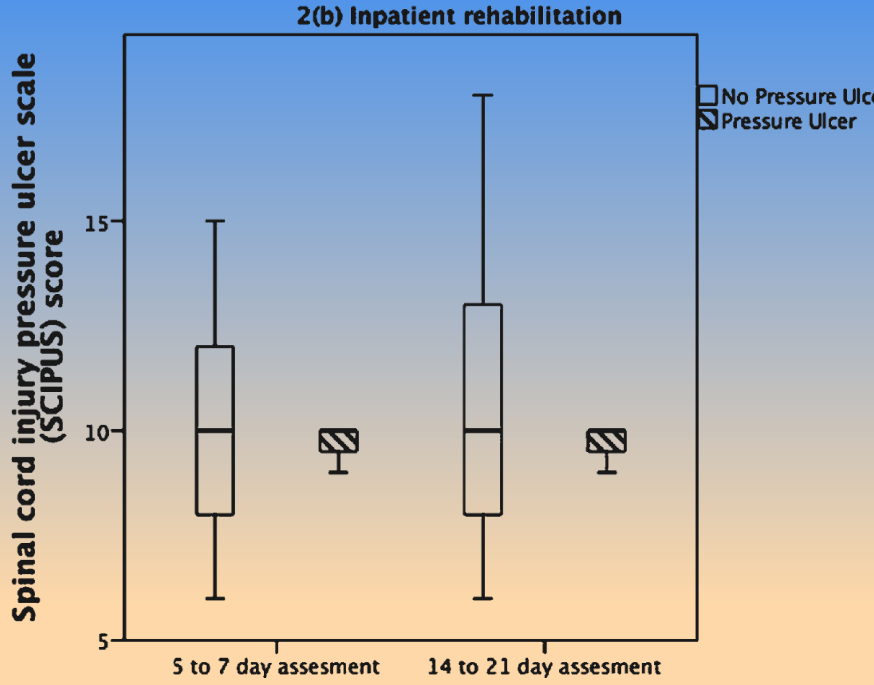
SCIPUS SCALE

- OVER 38 SCALES FOR PU PREDICTION- MOST STUDIED ARE BRADEN, NORTON, AND WATERLOO
- NO SCALE ADDRESS MOTOR IMMOBILTY AND SENSORY DEFICIT BELOW LEVEL OF INJURY
- SCIPUS HAS DEVELOPED 15 PARAMETERS IN 7 CATEGORIES (0 is absent, 1 or 2 if present)

1)Activity
2)Mobility
3)Severity (Complete, Autonomic Reflexia, or Severe spasticity)
4)Urine Incontinence
5)Pre-existing (tobacco, ag, Pulmonary disease, Cardiac Disease, DM/glucose, Renal Disease, Impaired cognitive function)
6)Residence in SNF or Hospital
7)Nutrition [Alb< 3.4 pr protein < 6.4 or Anemia (Hct < 36)]

SCIPUS





Predictive validity of the Spinal Cord Injury Pressure Ulcer Scale (SCIPUS) in acute care and inpatient rehabilitation in individuals with traumatic spinal cord injury Shilpa Krishnana et al NeuroRehabilitation 38 (2016) 401–409

FIM SCALE

FIM SCORE **RANGE 1- 7**

1. Self-care (6 items)

– Eating
– Grooming
– Bathing

– Dressing – Upper body
– Dressing – Lower body
– Toileting

2. Sphincter control (2 items)

– Bladder management
– Bowel management

3. Transfers (3 items)

– Bed/Chair/Wheelchair
– Toilet
– Tub/Shower

4. Locomotion (2 items)

– Walk/Wheelchair
– Stairs

Cognitive Domain:

5. Communication (2 items)

– Comprehension
– Expression

6. Social cognition (3 items)

– Social interaction
– Problem solving
– Memory

TOTAL **18-126**

SCI Scale Comparisons

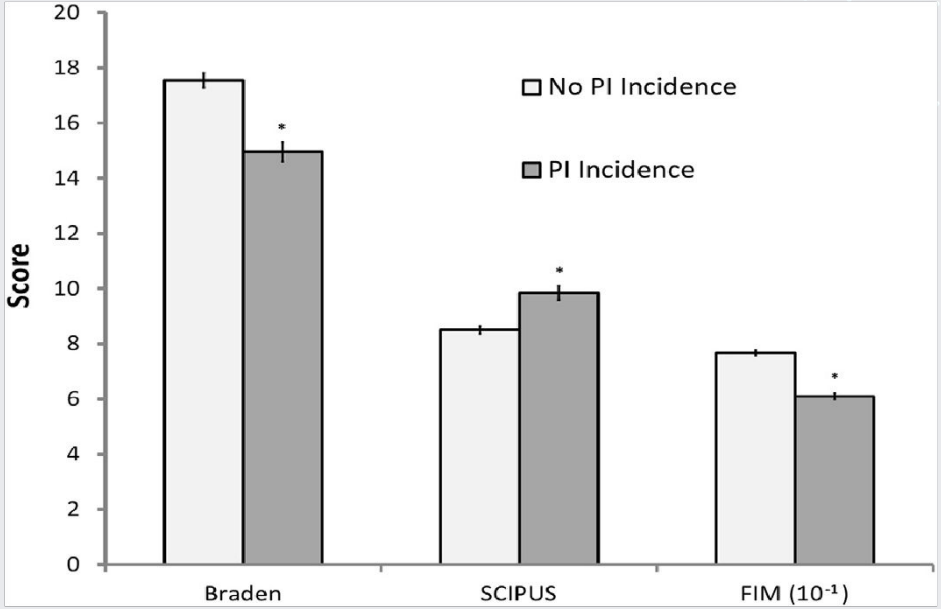


Fig 1 Mean differences in scores between outcome measure scores for individuals with and without PI incidence. *Significance at $P<.01$; error bars denote SEM. SCIPUS n = 571; Braden n = 173; FIM n = 615.

A Comparison of the FIM, Spinal Cord Injury Pressure Ulcer Scale, and Braden Scale , Heather M. Flett, BScPT, MSc Et al Archives of Physical Medicine and Rehabilitation 2019

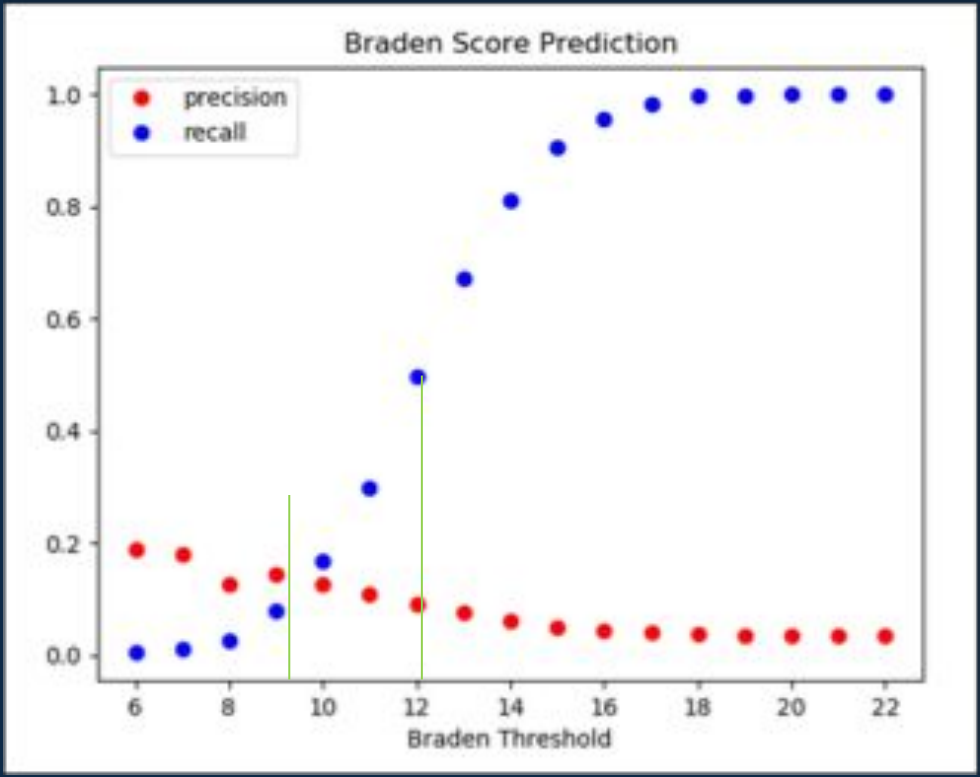
Machine Learning and PU prediction

- Stanford Study reviewing EHR data for approximately 54,000 patients admitted to the ICU of Beth Israel Deaconess Medical Center between 2001 and 2012

- 1,690 admissions where a PU was recorded on day 2 or beyond, evaluated the prognostic value of the Braden score measured within the first 24 hours.

- Trained a range of machine learning algorithms using demographic parameters, diagnosis codes, laboratory values and vitals available from the EHR within the first 24 hours.

Cramer, EM, Seneviratne, MG, Sharifi, H, Ozturk, A and Hernandez-Boussard, T 2019 Predicting the Incidence of Pressure Ulcers in the Intensive Care Unit Using Machine Learning . eGEMs (Generating Evidence & Methods to improve patient outcomes), 7(1): 49, pp. 1–11.



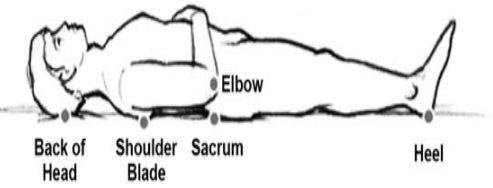
Precision @12- .09
Recall @12-.5

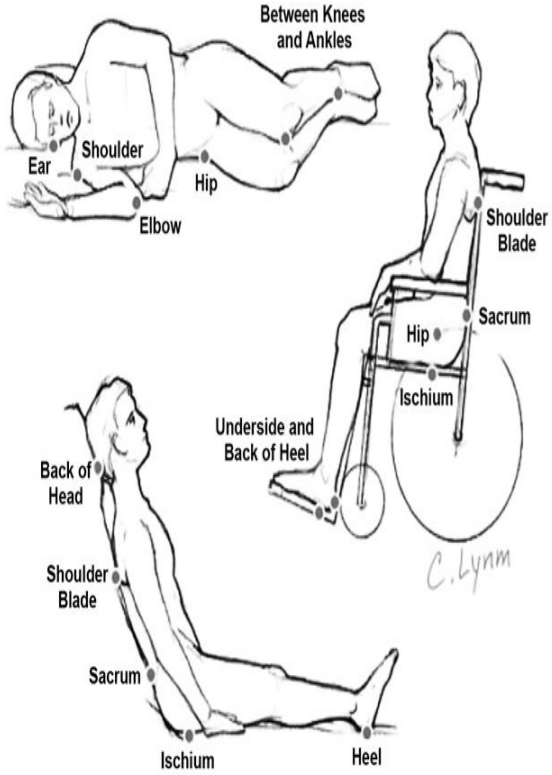
Precision @ 9 -.15
Recall - @9 - .08

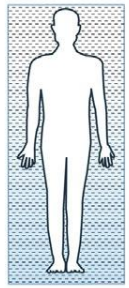
Top 10 of 40 Logistic regression Model

Weighted Logistic Regression	Carevue	All data	
Variable	**Standardized coeff.**	**Variable**	**Standardized coeff.**
Stage 1 PU within first 24h	2.0	GCS	−0.65
GCS	−0.46	Stage 1 PU within first 24h	2.1
BUN	0.28	BUN	0.4
paO_2	−0.36	paO_2	−0.37
Cardiac Surg. Recovery Unit	−0.79	Cardiac Surg. Recovery Unit	−0.88
Albumin	−0.39	Albumin	−0.41
Medical ICU	−0.59	Hemoglobin	−0.54
Pressure reduction device	0.89	Medical ICU	−0.53
Mechanical ventilation	0.61	Pressure reduction device	1.1
Mean arterial pressure	−0.19	Mean arterial pressure	−0.17

Precision of .09 and Recall of .71



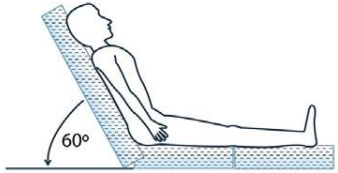




Prone Position

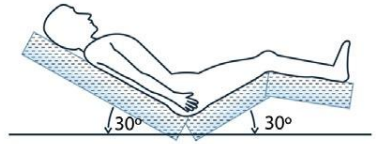
Supine Position 0°

Supine Position 30°

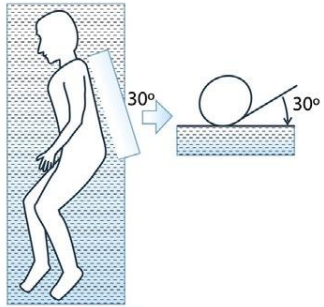


Supine Position 60°

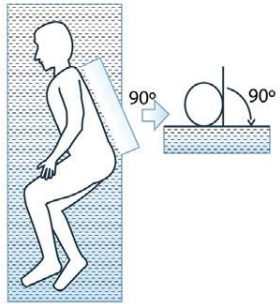
Supine Position 90°



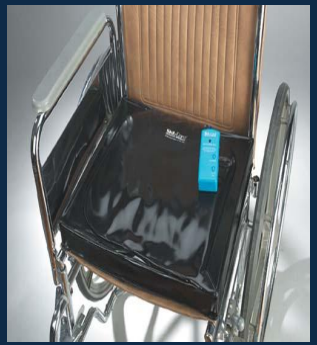
Semi-Fowler 30° - 30°



Lateral 30° Rotation



Lateral 90° Rotation



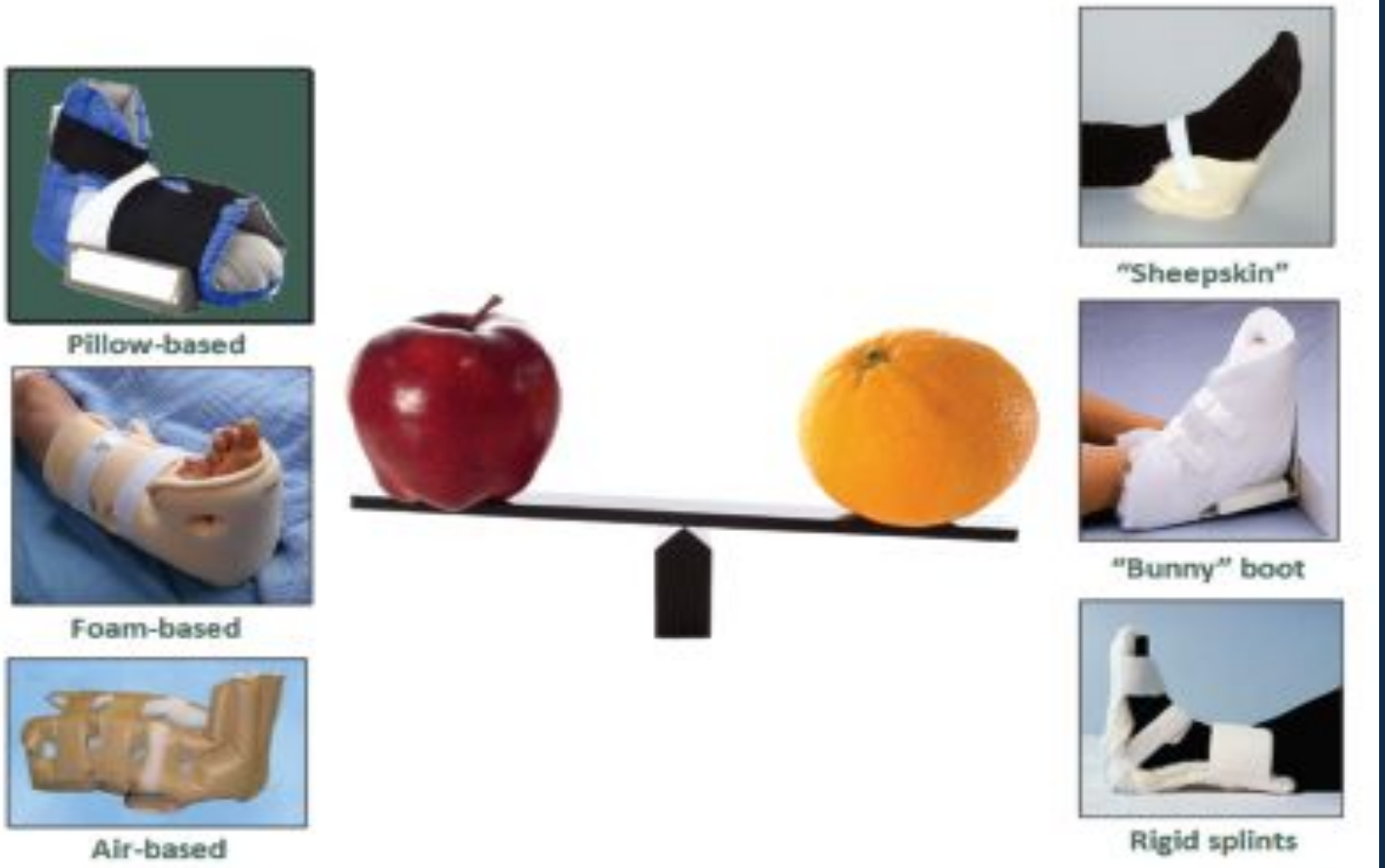


Figure 2. *Heel offloading devices (left) are not the same thing as heel padding devices (right)..*

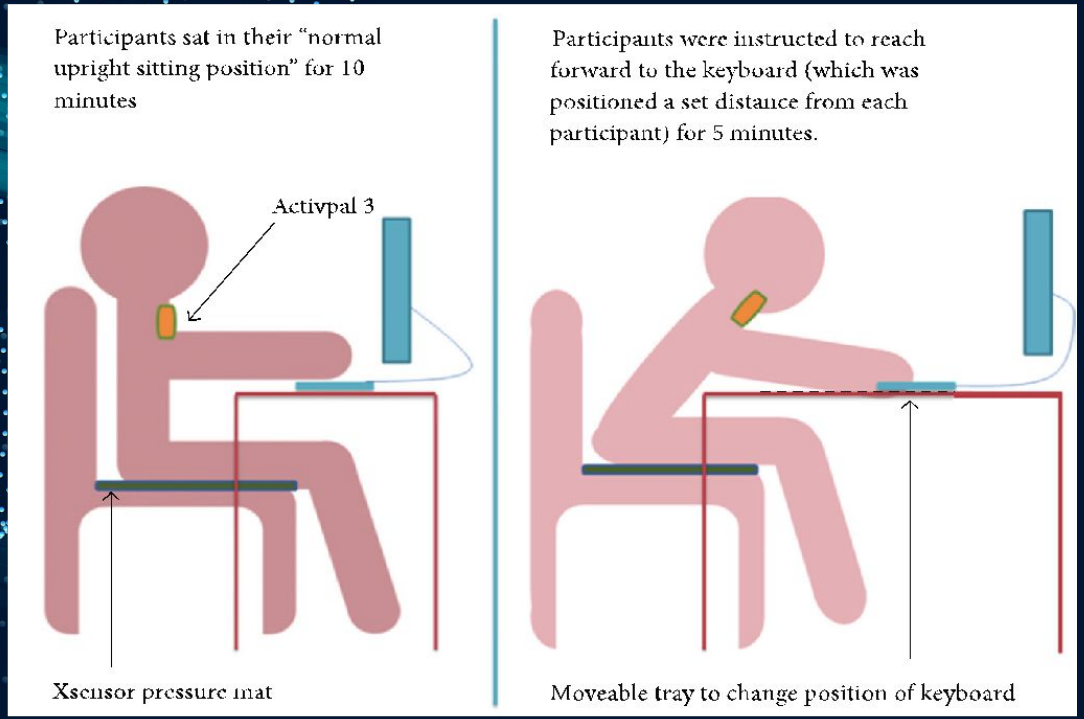
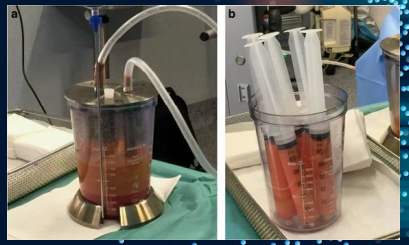


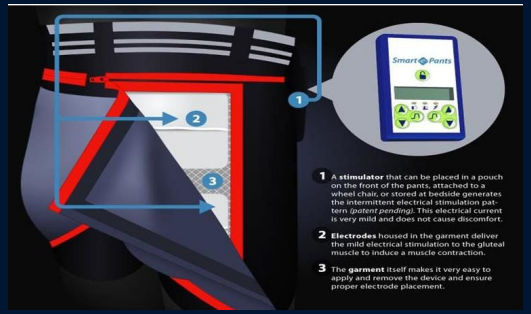
Figure 1: The positioning of equipment in Strand B.

Spinal Cord Injury and Pressure Ulcer Prevention: Using Functional Activity in Pressure Relief May Stinson, Nursing Research and Practice
Volume 2013

New Frontiers in Prediction and Prevention

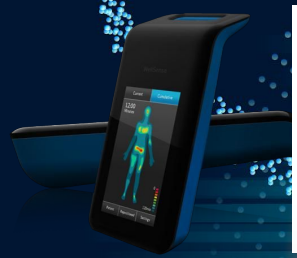
- Biomarkers – Circulatory adipose and myogenic gene expressions and correlation with IMAT
- Lipofilling
- Smart E Pants
- Bedside Technologies

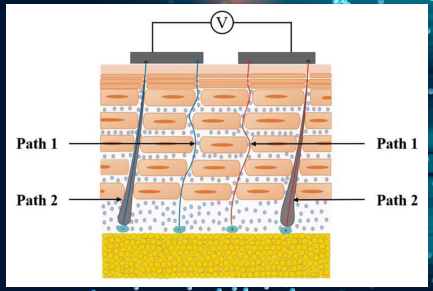


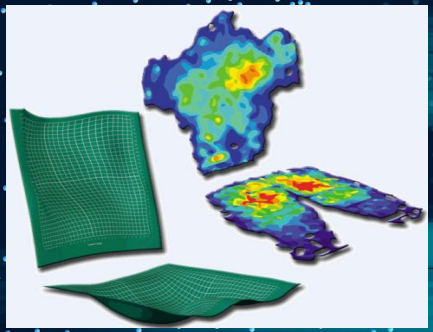


BEDSIDE EARLY DETECTION

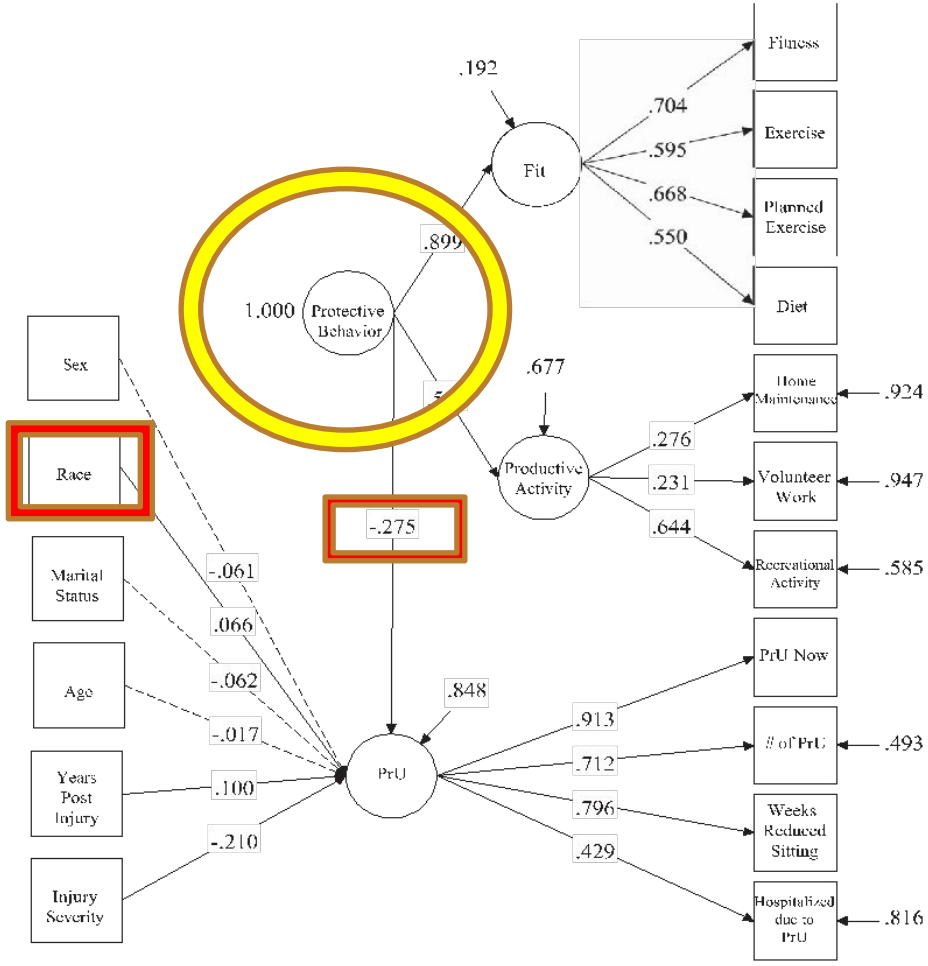
- Ultrasound
- Thermography
- Light Techonology
- Subepidermal Moisture Detection- - Capacitance
- Pressure Mapping /wireless matt sensors







Bedside Technologies to Enhance the Early Detection of Pressure Injuries
JWOCN March/April 2020



Note: A solid line indicates a significant effect and a dashed line indicates a non-significant effect.

A latent structural equation model of protective behaviors and pressure ulcer outcomes among people living with spinal cord injury C Li, ND DiPiro and J Krause . Spinal Cord (2017) 55, 135–140

SOCIAL NETWORKING

- 35 French Rehab centers with 1327 pts surveyed in initial post-tauma period of 2 years
- 11 yr follow up on 547 (221 died)
- 73% PU in the 1st period after injury
- 4 key factors for PU
  - Incomplete motor impairment – Odds ration of .5
  - Ability to walk – Odd ratio .2
  - PU during initial trauma phase – Odds 2.7
  - Lack of social network Odds 3.1

Risk Analyses of Pressure Ulcer in Tetraplegic Spinal Cord-Injured Persons: A French Long-Term Survey
Marc Le Fort, MD, MSc Archives of Physical Medicine and Rehabilitation 2017;98:1782-91

Summary

- Scales have imperfections.
- Simplicity and universal use makes Braden a convenient yet suboptimal choice
- Facilities need to incorporate scoring based on patient type and location
- Further research integrating EMR data and machine learning will allow multiparameter risk assessment
- Cost, ease of use and adoption lag may prohibit entry of new technologies
- Go back to the basics and provide custom solutions for each patient.

“Every battle is won before it is fought“

—Sun Tzu