Prediction of patient risk for serious complications from administrative and clinical data

11/6/08

Agenda

- How the “usual’ inpatient systems work
- Systems that use VS to predict patient mortality
  - Example - APACHE
- Systems that use VS to react to clinical deterioration more quickly
  - Rapid Response Teams
- Systems that use VS to measure clinical response
  - Goal directed therapy
- Use of administrative data to estimate risk and modify practice

Hospital sequence and Outcomes

SEQUENCE

- Diagnosis

1. Treatment
2. Evaluation
3. Modification
4. Re-evaluation
5. Recovery or death

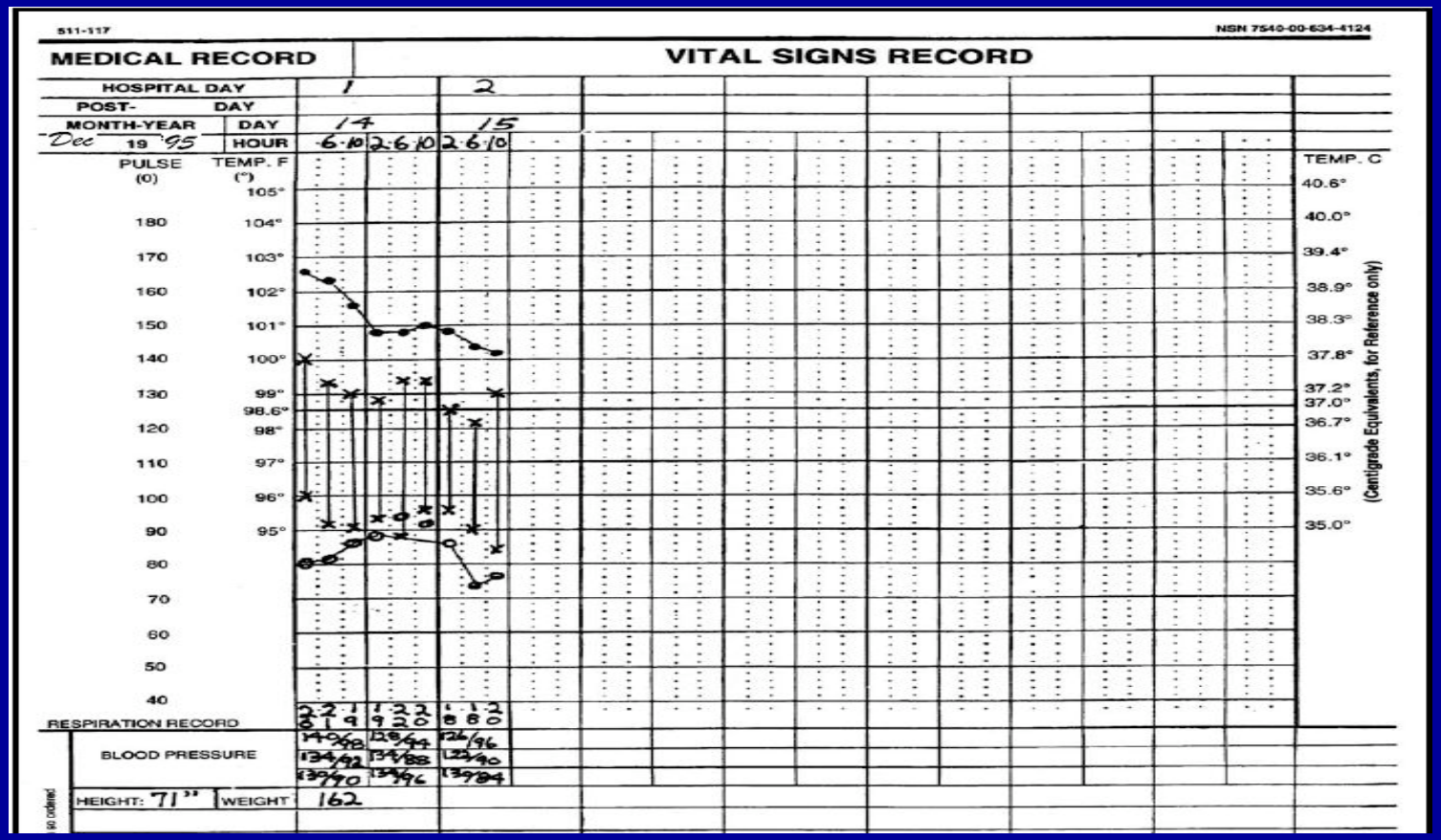
OUTCOMES

- Expected, successful
- Expected, unsuccessful
- Unexpected
  - Recoverable
  - Not recoverable

Typical inpatient experience

- Admitted for complicated procedure or serious illness
- Placed in a bed with call bell
- 1 nurse for several patients
  - 1:5 Med-Surg (California)
- Vitals (P,BP,T,RR,O_2 Sat,Pain) monitored by aide every 4-8 hours. Values transcribed to bedside chart. Input and output recorded and totaled daily
- Vitals records/graphs removed every several days

In use in over 90% of hospitals



A secret: It takes a very bright thoughtful clinician to pick up early patterns of concern.

Typical ICU experience

- Admitted for immediately life-threatening illness
- Placed in a bed with automated monitor (P,BP,T,RR,O_2 Sat, EKG Rhythm)
  - May add invasive monitors (Swan Ganz, arterial line)
- 1 nurse per patient, patients in direct line of sight
- Most ICU's "closed", Intensivist available most of day, often 24/7
- Vitals & labs transcribed to bedside flowsheets.
- Input and output recorded and totaled each shift.

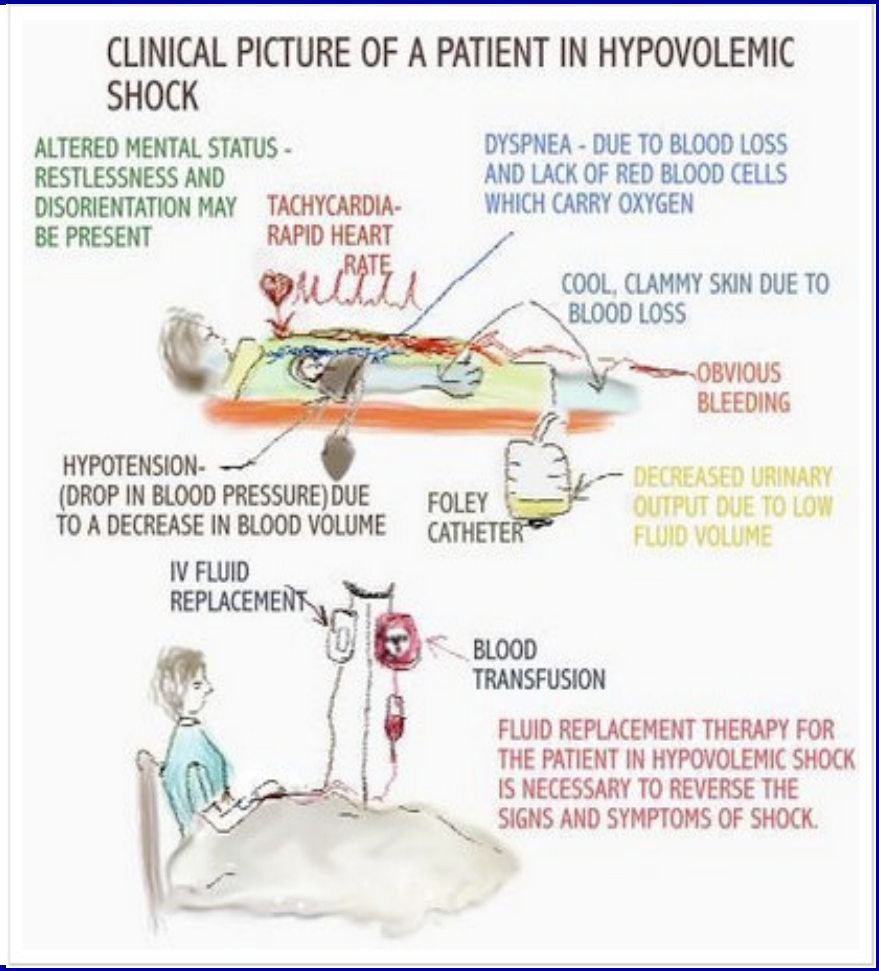
How doctors relate to VS

- Traditional:
  - Rounds between 6:30 and 8 am
  - In office or OR 9-5
  - Rounds after 5 (selected patients)
  - "Call for T≥ 38.5, Pulse ≥120, RR ≥ 26, BP ≤ 80 Systolic"
  - "Titrate O_2 to sat ≥ 92%"
  - Phone call from RN
- Hospitalist/Intensivist
  - Available all day

Important emergencies-
Vitals change in typical pattern

TABLE 1. Potential sepsis-related markers

General variables
Temperature > 38.3 °C or < 36.0 °C
Heart rate > 90 beats/min
Tachypnea (respiratory rate > 20 breaths/min in adults)
Altered mental status
Inflammatory response variables
White blood cell count > 12 000 cells/μL, < 4 000 cells/μL, or with > 10% immature forms
Plasma C-reactive protein > 2 standard deviations above the normal value
Plasma procalcitonin > 2 standard deviations above the normal value
Hemodynamic variables
Systolic blood pressure < 90 mmHg or mean arterial blood pressure < 70 mmHg
Mixed venous oxygen saturation > 70%
Cardiac index > 3.5 L/min/m^2
Organ dysfunction variables
PaO_2/FiO_2 < 300
Urine output < 0.5 mL/kg/hr or creatinine increase > 0.5 mg/dL
International normalized ratio > 1.5 or activated partial thromboplastin time > 60 sec
Platelet count < 100 000 cells/μL
Plasma total bilirubin > 4 mg/dL
Tissue perfusion variables
Hyperlactatemia > 1 mmol/L
Decreased capillary refill or mottling



Characteristics of “usual” use of vital signs data

- Retrospective review, significant lag times
- Reactive
- Changes non-specific
  - Additional investigation/diagnostic tests often required to identify cause of change
- Some unreliable (RR, improperly used equipment)
- Lack important information (eg. RR cannot indicate ventilation status)
- Not integrated

Characteristics of “optimal” use of vital signs data

- Real time review, no significant lag times
- Proactive, allow for early intervention
- Changes integrated to distinguish most likely etiology, eg:
  - Hypovolemia
  - Sepsis
  - Cardiogenic shock
  - Respiratory failure
- Change “data” to “information”
- Reliable (eg. Accurate end tidal CO_2 rather than estimated RR)
- Smart Alarms

Agenda

- How the “usual’ inpatient systems work
- Systems to predict patient mortality
  - Example - APACHE
- Systems that react to clinical deterioration more quickly
  - Rapid Response Teams
- Systems targeting clinical response
  - Goal directed therapy
- Use of administrative data to estimate risk and modify practice

Acute Physiology and Chronic Health Evaluation

- Uses basic information available at the time of admission to an ICU to predict mortality and ICU length of stay
- Change in score over 24 - 48 hours provides additional prognostic information

APACHE IV input values

- Highest and lowest
  - Temperature
  - Systolic BP
  - Diastolic BP
  - Pulse
  - Respiratory rate
- Urine output (24 hr)
- Glasgow Coma Score
- Age
- Specific Chronic Medical Problems
- Ventilated?
- Emergency Surgery
- Readmission?
- Highest and lowest
  - Sodium
  - Glucose
  - Creatinine
  - BUN
  - HCT (%)
  - WBC
- Albumin
- Bilirubin
- pH, pO2, pCO2, FiO2

APACHE Chronic health Conditions

- CRF/HD
- AIDS
- Hepatic Failure
- Lymphoma
- Metastatic Cancer
- Leukemia/MM
- Immunosuppression
- Cirrhosis

Agenda

- How the “usual’ inpatient systems work
- Systems to predict patient mortality
  - Example - APACHE
- Systems that react to clinical deterioration more quickly
  - Rapid Response Teams
- Systems targeting clinical response
  - Goal directed therapy
- Use of administrative data to estimate risk and modify practice

Rapid Response Teams

- Designed to bring care immediately to inpatients with sudden change in status
- Can be called by any concerned clinician
- Emergency page/Vocera to ICU MD&RN, Respiratory, Anaesthesia

Criteria to activate rapid response team

- Acute change in heart rate < 40 or > 130 bpm
- Acute change in systolic blood pressure < 90 mmHg
- Acute change in respiratory rate < 8 or > 28 per min
- Acute change in saturation < 90 percent despite O2
- Acute change in conscious state
- Acute change in urinary output to < 50 ml in 4 hours

Rapid Response Team Results

Measure:	Before:	After:	Rel Risk Reduction:
No. cardiac arrests	63	22	65% (p=.001)
Deaths from cardiac arrest	37	16	56% (p=.005)
No. days in ICU post arrest	163	33	80% (p=.001)
No. days in hospital post arrest	1363	159	88% (p=.001)
Inpatient Deaths	302	222	25% (p=.004)

Medical Journal of Australia. 2003;179(6):283-287.

Goal Directed Therapy for Sepsis

- Sepsis is a major cause of death
- Fluid resuscitation is the cornerstone of therapy, with pressors and antibiotics
- Use of specific targets for post resuscitation BP, pulse, and other parameters is associated with improved survival

Use of administrative data

- Data Elements
  - Demographics (age, insurance)
  - Route of entry (eg. ED, transfer, SNF)
  - ICD-9 diagnostic codes
    - Available from integrated EMR
    - Available from concurrent coding
- For each DRG, multivariate analyses have identified additional ICD-9 codes that modify the risk of mortality
- Can define populations at highest risk for special interventions
  - Acute Care of the Elderly (ACE) teams
  - CHF, MI, etc

My wish list for Vital Signs

- Trended, accurate data available in real time and remotely
- Pattern recognition software for decision support
- Better respiratory measurements
  - RR and O_2 Sat insufficient
  - Arterial blood gas invasive
  - Need convenient measurement of ventilation (eg. pCO_2)
- Measures of tissue perfusion
- Integration with lab/clinical findings

Current drivers - apart from the bottom line

- Better care
- Hospital quality measures
  - Risk adjusted mortality
  - AHRQ patient safety indicators, CMS “Never Events”, JC goals…..
    - “Failure to rescue”
    - “Death in low mortality DRG”
    - “Selected infections due to medical care”
    - “Post operative respiratory failure”