Cardio-Pulmonary Exercise Testing

概述：它是什么

动机：为什么我们需要它

过程：它是如何完成的

解释

临床应用

要点

 Disclosures

- 无

“我的工作让我头痛，血压高，胸痛，胃出血。我会放弃，但我喜欢他们的健康计划。”

Outline

- 概述：是什么
- 动机：为什么我们需要它
- 过程：它是如何完成的
- 解释
- 临床应用
- 要点

什么是CPET？

- 功能性能力
  - O₂供应到组织
  - CO₂清除
- 这个系统上的压力具有预测价值
- 模拟手术经验测试功能性能力的应力耐受

在基本水平

VQ配比

- 运动诱导
  - 通风量增加
  - 血液灌注增加
- 疾病状态将影响一方或双方
- 测试可以检测不匹配
Cardio-Pulmonary Exercise Testing

- Global assessment
- Exercise responses of
  - Pulmonary
  - Cardiovascular
  - Hematopoietic
  - Neuropsychological
  - Musculo-skeletal

Why do we need CPET?

Cardiorespiratory Fitness as a Quantitative Predictor of All-Cause Mortality and Cardiovascular Events in Healthy Men and Women

- Meta analysis of 33 studies
- >185,000 participants
- All-cause mortality and CHD/CVD outcome
  - 1 MET higher level of MAC
  - 13% risk reduction of ACM
  - 15% risk reduction of CHD/CVD

Survival of the fittest...

Exercise Capacity and Mortality among Men Referred for Exercise Testing

- Exercise capacity is a more powerful predictor of mortality among men than other established risk factors of cardiovascular disease

Survival of the fittest...

Total mortality after changes in leisure time physical activity in 50 year old men: 35 year follow-up of population based cohort

- 2,205 men aged 50
- 35-year follow up
Those that increased physical activity reduced their mortality risk.

Risk Reduction Equivalent to Smoking Cessation

Timeline

- Prehab
- Baseline
- Surgery
- Recovery
- Rehab
- Full Recovery

How is it done?

Equipment

- Gas Analyzer
- Pneumotachograph
- Computer
- 12-lead EKG
- Display
- Physiological Parameters
- VO₂
- VCO₂
- Static Cycle
How is it done?

**Equipment**
- Gas Analyzer
- Computer
- Display Physiological Parameters
- Static Cycle

**How is it done?**

- Breath-by-breath gas analysis
  - Oxygen uptake - VO2
  - CO2 production - VCO2
- Graded exercise challenge
  - Treadmill vs. bike
- Peak Oxygen Consumption (VO2 max)
- Anaerobic Threshold (AT)

**Measurements**
- Max aerobic capacity (VO2max)
- Anaerobic Threshold (AT)
- Oxygen Pulse (VO2/HR)
- Vent Equivalents (VE)
  - Oxygen (VE/VO2)
  - Carbon Dioxide (VE/VCO2)

**Calculations**

**Ventilatory Threshold**
- Submaximal index of exercise capacity
- VE increases exponentially relative to VO2
- VE required to eliminate CO2
- Point at which O2 requirements exceed supply – anaerobic metabolism begins – lactate production rises
- Occurs at approx. 45-65% VO2max
- Not under voluntary control. Not affected by psychological factors
Calculations

Ventilatory Threshold

Work Rate
- VO2
- VCO2
- HR
- NIBP
- VT
- VE
- RR

Gas Exchange

Cardiovascular

Respiratory

Interpretation

Variable Normal Value

VO2Max ≥84% predicted
VT/AT ≥40% of VO2Max (up to 80%)
HR ≥90% age predicted
BP <220/90
O2 Pulse (VO2/HR) ≥80%
Resp Rate <60/min
VE/VCO2 (at VT) ≤54
PaO2 ≥80 mm Hg
P(A−a)O2 ≤35 mm Hg

In specific clinical settings

Measurement CHF COPD ILD Obesity Deconditioning

VO2Max ↓ ↓ ↓ ↓ for IBW ↓
VT ↓ N or ↓ N or ↓ N or ↓
Peak HR Variable N or ↓ ↓ N or ↓ N or ↓
O2 Pulse ↓ N or ↓ N or ↓ N or ↓
VE/VCO2 ↑ ↑ ↑ N N
PaO2 Variable ↓ N or ↑ N
P(A−a)O2 N Variable or ↑ N or ↑ N

Interpretation

- Exercise tolerance
- CV disease
- Respiratory disease
- Preoperative evaluation
- Pulmonary rehab
- Disability assessment
- Pre-thoracic transplant
Survival/risk threshold

- 187 elderly patients
- Abdominal surgery
- Overall mortality = 7.5%

VT/AT N Periop Mortality
>11 ml/min/Kg 132/187 0.8%
<11 ml/min/kg 55/187 18%
<11 ml/min/kg + ischemia 8/19 42%

548 Patients > 60y
Abdominal surgery
Postop location (ICU/HDU/Ward) assigned on basis of preop VT+ischemia
Mortality = 3.9%

Triage Postop Location

Overall & CV Mortality

Cardiorespiratory Fitness Predicts Mortality and Hospital Length of Stay After Major Elective Surgery in Older People.

Overview
Rationale
Process
Interpretation
Clinical applications
Key points

• 25 patients with operable lung cx
• 5 endurance sessions @ 60-100% Peak VO2
• CPX at baseline, immed before and 30d after surgery

Does intervention improve outcome?

Lung cancer

- Modest increase in peak VO2
- Some benefit in those who had >80% adherence
- Fitness level decreased after surgery, but not below baseline

Total Joint Replacement

- No beneficial effects on postop functional recovery
- Therapeutic validity of exercise regimes was questionable
- Poor quality data
- Larger trials needed…

Therapeutic Validity and Effectiveness of Preoperative Exercise on Functional Recovery after Joint Replacement: A Systematic Review and Meta-Analysis
Hoogeboom, TL, et al. PLOS One 7(5): e38031

• 737 patients from 12 trials
• Resistance, aerobic or functional exercise in TKR and THR
• 2.5 times/week x 6 weeks

Cardiorespiratory fitness was not validated.
Does intervention improve outcome?

Impact of preoperative change in physical function on postoperative recovery: Argument supporting prehabilitation for colorectal surgery

Mayo NE, et al.

Surgery 2011. 150(3): 505-514

- Reanalysis of a prehab RCT
- Primary outcome - 6MWT
- Secondary outcomes – mental health/complications
- 95 patients completed prehab
- 75 also assessed postop (9 w)

Impact of preoperative change in physical function on postoperative recovery: Argument supporting prehabilitation for colorectal surgery

Mayo NE, et al.

Surgery 2011. 150(3): 505-514

- 33% improved mental health, exercise capacity
- Women less likely to improve
- Preop improvement more likely to return to baseline
- 29% deteriorated – more complications
- "Meaningful" changes in functional capacity achieved
- Those with poor capacity should consider prehab

The effects of preoperative exercise therapy on postoperative outcome: a systematic review

Valkenet, K et al.

Clinical Rehabilitation. 2011;25(2):99-111

- 12 studies – JR (n=7), abdominal (n=1), cardiac (n=4)
- Methodological quality rated using PEDro scale
- Preop Exercise: improves LOS in Cardi/Abd, not in JR
- Inspiratory muscle training: reduces postop pulm complications
- Use intervention in targeted manner

How do you get one for your patient?

- Order the CARD
  Cardiopulmonary Stress Test
- Call 919-684-2080 to schedule
- Managed by CDU

Equipment

VIAsprint™ 150P and Ergoselect 600
Recumbent Ergometer (BD Inc, NJ)

GE T2100 Treadmill. (GE Inc)

Vmax® Encore Metabolic Cart with complete PFT system (BD Inc, NJ)
Take home points

• Preoperative functional capacity is a powerful predictor of adverse outcome
• CPX testing can detect subtle and overt reductions in functional capacity
• Interventions have yielded marginal results
• Reductions in LOS and complications in selected groups have offered hope

Recommended reading