AUTONOMIC FUNCTION IS A HIGH PRIORITY

‘an ailment not to be treated’

Modified from Anderson 2004
CARDIOVASCULAR AUTONOMIC PATHWAYS

Parasympathetic:
Unaffected by SCI

Sympathetic:
Control of the heart at T1-T5
Control of the vasculature T1-L2
Splanchnic: T6-T10

Modified from Inskip 2009
CARDIOVASCULAR AUTONOMIC DYSFUNCTION

Low resting blood pressure

Orthostatic hypotension (OH)

Autonomic dysreflexia (AD)

Modified from Blackmer, 2003
MANY CARDIOVASCULAR CONSEQUENCES OF INTERRUPTED SYMPATHETIC PATHWAYS
ROLE IN CARDIOVASCULAR DISEASE RISK

- Autonomic dysfunction
- Lifestyle
  - Physical activity
- Risk for Cardiovascular Disease
Prevalence of cardiovascular autonomic dysfunction

Contribution of autonomic dysfunction to cardiovascular disease risk

Waist circumference: the best marker for obesity after SCI

ECG-based predictors for cardiac arrhythmias after SCI
Autonomic dysfunction only recently included in standard AIS assessment

Changes over time not yet investigated
AIMS

I. to determine the prevalence of hypotension during and after inpatient rehabilitation

II. to investigate the time course of blood pressure, resting and peak heart rate, during and after inpatient rehabilitation

III. to evaluate the influence of personal and lesion characteristics on these cardiovascular variables
STUDY METHODS

197 participants with SCI

Characteristics:
- Age & sex
- AIS score
- Time since injury
- Medical history

Cardiovascular variables:
- Resting blood pressure
- Resting heart rate
- Peak heart rate (exercise)
- Hypotension

Time points:
- Start of rehabilitation
- Discharge
- 3 months
- 1 year
- 2 years
- 5 years
PREVALENCE OF HYPOTENSION

Time course:
no change

Lesion level (cervical):
Odds 4.2 times greater than low lesion group
Odds 2.7 times greater than high thoracic group

Age:
Odds decreased with age, 0.75 per 10-years

Sex:
Men 2.2 times greater odds
BLOOD PRESSURE AND HEART RATE CHANGES OVER TIME

**A**

![Graph: Systolic arterial pressure (mmHg)]
- Cervical
- High thoracic
- Low

<table>
<thead>
<tr>
<th>Time</th>
<th>Cervical</th>
<th>High thoracic</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
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<td>3 months</td>
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<td>5 years</td>
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**B**

![Graph: Diastolic arterial pressure (mmHg)]
- Cervical
- High thoracic
- Low

<table>
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**Resting Heart Rate (BPM)**

![Graph: Resting Heart Rate (BPM)]
- Cervical
- High thoracic
- Low

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**Peak Heart Rate (BPM)**

![Graph: Peak Heart Rate (BPM)]
- Cervical
- High thoracic
- Low

<table>
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</table>
Hypotension was common after spinal cord injury

Impaired heart rate response to exercise

Cardiovascular dysfunction mostly after cervical lesions

No improvement over time
Prevalence of cardiovascular autonomic dysfunction

Contribution of autonomic dysfunction to cardiovascular disease risk

Waist circumference: the best marker for obesity after SCI

ECG-based predictors for cardiac arrhythmias after SCI
CONTRIBUTION OF AUTONOMIC DYSFUNCTION TO CARDIOVASCULAR DISEASE RISK

Lifestyle
Physical activity

Autonomic dysfunction

Low blood pressure
Fatigue
Barrier participation physical activity

Deficient increase in heart rate
Insufficient perfusion of muscles
Poor exercise tolerance

Sympathetic control interrupted
Leptin effects impaired
Resting metabolic rate decreased

Insulin receptor function
Insulin sensitivity

Risk for Cardiovascular Disease

Autonomic dysfunction

SFU
AIMS

I. to determine the differences in cardiovascular disease risk between those with and without cardiovascular autonomic impairment after SCI, and able-bodied controls

II. to investigate the contribution of autonomic impairments, physical activity levels, and their interaction to cardiovascular disease risk after SCI
Plasma noradrenaline:
cut-off < 0.56 nmol/L

Low frequency systolic pressure variability:
cut-off < 1.0 mmHg²
STUDY METHODS:
CVD RISK FACTORS AND PHYSICAL ACTIVITY LEVEL

Cardiovascular disease risk factors:
- Blood lipid profile
- Insulin
- Glucose
- Glucose tolerance
- Insulin resistance (HOMA)

Framingham cardiovascular disease risk score:
- Age
- Total cholesterol
- Smoking status
- Anti-hypertensive treatment
- Sex
- HDL cholesterol
- Diabetes
- Systolic pressure

Physical activity level:
- Physical Activity Scale for Individuals with Physical Disabilities
STUDY METHODS: MULTIPLE REGRESSION ANALYSES

Outcome measures:
- Framingham risk score
- Other risk factors

Independent variables:
- Autonomic function (plasma NA)
- Physical activity level (PASIPD score)
- Interaction effect

Confounder variables:
- Age
- Sex
- Waist circumference
# MULTIPLE REGRESSION ANALYSES RESULTS

<table>
<thead>
<tr>
<th></th>
<th>Framingham risk score</th>
<th>120 min glucose</th>
<th>Insulin resistance</th>
<th>Insulin</th>
<th>Triglyceride</th>
<th>HDL</th>
<th>TC/HDL ratio</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-27.7 (10.4)</td>
<td>-4.1 (1.0)</td>
<td>1.4 (0.2)</td>
<td>7.0 (0.7)</td>
<td>-0.58 (0.6)</td>
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<td>-1.28 (1.5)</td>
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<tr>
<td>Autonomic function</td>
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<td>-0.37 (0.12)</td>
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<td>Physical activity</td>
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<td>Interaction</td>
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<td>0.02 (0.01)</td>
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<td>Age</td>
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<tr>
<td>Sex</td>
<td>NE</td>
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<tr>
<td>Waist circumference</td>
<td>0.47 (0.12)</td>
<td>NE</td>
<td>NE</td>
<td>NE</td>
<td>0.03 (0.01)</td>
<td>-0.01 (0.005)</td>
<td>0.08 (0.02)</td>
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</table>
CONCLUSIONS

Autonomic impairment contributes to overall risk of cardiovascular disease

Direct or indirect effects of autonomic impairment were shown for all glucose regulation variables

No effect was found of autonomic impairment on lipid profile variables
Prevalence of cardiovascular autonomic dysfunction

Contribution of autonomic dysfunction to cardiovascular disease risk

Waist circumference: the best marker for obesity after SCI

ECG-based predictors for cardiac arrhythmias after SCI
Problems with existing obesity indices:

Challenging measurements

General cut-off values

Edwards et al. 2008
AIM

To identify the best marker for obesity-related CVD risk for those with SCI, considering:

i. practicality of use
ii. ability to detect adiposity and CVD risk
STUDY METHODS

27 participants with chronic SCI

Anthropometric measures:
- Waist circumference (WC)
- Waist-to-height ratio (WHtR)
- Waist-to-hip ratio (WHR)

Body composition (DEXA):
- Fat percentage
- Abdominal fat percentage

Framingham cardiovascular disease risk score
BMI, WC AND WHtR ARE CORRELATED WITH ABDOMINAL FAT PERCENTAGE
WC CORRELATED BEST WITH RISK SCORE

A

Framingham risk score

Sensitivity

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

1-Specificity

AUC = 0.92

r = 0.655
p = 0.0007

B

Framingham risk score

Sensitivity

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

1-Specificity

AUC = 0.92

r = 0.596
p = 0.003

C

Sensitivity

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

1-Specificity

AUC = 0.92

WHtR

D

Sensitivity

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

1-Specificity

AUC = 0.87

WHtR

r = 0.655
p = 0.0007

r = 0.596
p = 0.003
CONCLUSIONS

Waist circumference is the best measure: *simple and sensitive*

Optimal cut-off from this sample: 94 cm
GENERAL CONCLUSIONS

Cardiovascular autonomic dysfunction especially prevalent in those with high level lesions and it does not show improvement into the chronic stage.

Autonomic dysfunction plays a role in the increased risk of cardiovascular disease.

Important to quantify autonomic impairment as part of the standard assessment.

Waist circumference (with a specific cut off) is the best, simple index for obesity-related cardiovascular disease risk.

ECG parameters Tp-Te, QTVI and P-wave variability could be used to determine susceptibility to cardiac arrhythmias.
THANK YOU

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Jessica Inskip
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Maureen McGrath

Inderjeet Sahota
Brett Shaw
Mike Walsh