Carpal Tunnel Syndrome
Work-Relatedness from an Epidemiologic Perspective

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Disclosure
Will not discuss off-label use and/or investigational use in this presentation.
No financial relationships to disclose.

Objectives
• Identify the strengths and weaknesses in the epidemiologic arguments that are used to support or refute the relationship of work activities as risk factors for carpal tunnel syndrome (CTS)
• Form your own opinion as to whether there is sufficient epidemiologic evidence to support the concept of "work-related CTS"
• Understand the knowledge gaps that future studies may address

Outline
• Diagnostic Difficulties
• Carpal Tunnel Syndrome Incidence
• Gender Differences
• Computer users survey

Emergency Room
• 31 y/o auto detailer presents to ED for evaluation of 3 weeks of hand numbness and tingling, worse with gripping and while at work, all fingers affected, no neck pain or foot numbness
• No deformity. No swelling. Tender to palpation. No scaphoid tenderness. Full range of motion. Capillary refill less than 2 seconds. 5/5 strength with finger flex/ext and intrinsic muscles of the hands. Temperature sensation normal. Proprioception normal. 3–4mm two-point discrimination. Sharp and dull discrimination intact in both hands. Symmetrical and diffuse hand/finger numbness.

Primary Care
• 31-year-old gentleman with 3 wk hx of numbness, tingling, and weakness in both hands. Started working at a car dealership detailing new cars 2 months ago. Uses power washers and vacuum cleaners that require repetitive wrist flex/ext most of the day. Unable to differentiate which fingers involved. Prescribed wrist splints in ED. Some relief; but, it is difficult for him to do his job. History of depression. Celexa controlled his depression symptoms, but he ran out a month ago. Worsening depression since.
• Strength and sensation normal in both upper and lower extremities. No intrinsic muscle atrophy. Tinel and Phalen positive bilaterally.
Work Rehab Center

- 31-y/o ambidextrous gentleman without previous hand problems. About 8-9 yrs ago worked in auto detailing, last 4 years worked at Kwik Trip. Resumed auto detailing 2 months ago. Uses buffer, hand-intensive cleaning activities. Two wks ago, hands hurt to the point that he could not handle equipment. Difficulty squeezing bottles and working with air hoses. Diffuse pain in both hands, tingling in all fingers, worse with activity.
- Obese. Tenderness over volar and dorsal wrists; over thumb, abductor/extensor muscles; and over forearm extensor muscles bilaterally. Full finger and wrist motion. Paresthesias in all digits with Tinel’s and Phalen’s bilaterally. Finkelstein’s positive bilaterally. Strength normal. Reflexes normal. Pinprick normal.

Questions

- What is your diagnosis?
- Is an EMG necessary or helpful to confirm the diagnosis in this patient?
- Is the current medical condition “work-related”?
- Would being thin change your opinion?
- Would being female change your opinion?
- Would a different occupation change your opinion?

Diagnostic Difficulties

- No gold standard for CTS
- CTS can be defined clinically
- Median neuropathy can be measured objectively with electrodiagnostic studies (EDS)
- Poor agreement between symptoms, PE and EMG findings (Homan et al, 1999)
- Different specialists vary in the importance they assign to various clinical criteria for diagnosis (Graham et al, 2006)
- Hand diagrams (Dale et al, 2008)
  - High reliability but phone interview better
  - Disagreement associated with presence of symptoms other than classic CTS symptoms

Classification of Symptom Quality and Location for Use With Hand Diagrams or Focused Questions

Estimated likelihood of Carpal Tunnel Syndrome (CTS) for Case Definitions of CTS that Include Electrodiagnostic Studies (EDS)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>EDS</th>
<th>Ordinal Likelihood of CTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic/probable</td>
<td>Positive</td>
<td>+++</td>
</tr>
<tr>
<td>Possible</td>
<td>Positive</td>
<td>++</td>
</tr>
<tr>
<td>Classic/probable</td>
<td>Negative</td>
<td>+/-</td>
</tr>
<tr>
<td>Possible</td>
<td>Negative</td>
<td>-</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Positive</td>
<td>-</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Negative</td>
<td>-</td>
</tr>
</tbody>
</table>

* No consensus achieved on whether likelihood should be - or +

Bernardino Ramazzini (1713)

“The maladies that affect the clerks (secretaries/transcriptionists) aforesaid arise from three causes:

First, constant sitting (Sedentary),

secondly, the incessant movement of the hand and always in the same direction (Repetitive),

thirdly, the strain on the mind from the effort not to disfigure the books by errors or cause loss to their employers when they add, subtract, or do other sums in arithmetic (Stressful).”

--- De Morbis Artificum Diatriba (1713), Supplement, Ch. II
<table>
<thead>
<tr>
<th>Arm Pain</th>
<th>Carpal Tunnel Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>• DeQuervain 1895</td>
<td>• George Vivian Poore 1873, 1878</td>
</tr>
<tr>
<td>• Kocher (mentor) “a passive type of work hypertrophy”</td>
<td>• Case report and case series of writer’s cramp</td>
</tr>
<tr>
<td>• R N Wilson 1957</td>
<td>• James Ramsey Hunt 1909</td>
</tr>
<tr>
<td>• Tenosynovitis in industry</td>
<td>• Thenar atrophy, “occupational neuritis”</td>
</tr>
<tr>
<td>• Shattuck Hartwell, Jr. 1964</td>
<td>• Walter Russell Brain 1947</td>
</tr>
<tr>
<td>• Tenosynovitis in women in industry</td>
<td>• Implicated occupation as a causal factor</td>
</tr>
<tr>
<td>• Leo Hymovich 1966</td>
<td>• “...working women cannot give up manual work for the rest of their lives.”</td>
</tr>
<tr>
<td>• Medical director at Bunker Ramo Corporation</td>
<td>• K W G Heathfield 1957</td>
</tr>
<tr>
<td>• Case series of injuries in workers (computer manufacturing)</td>
<td>• Described 80 CTS cases, noting an association with occupation, pregnancy, DM, and OA</td>
</tr>
<tr>
<td>• Muscle pain with/without tenosynovitis was result of repetitive motions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carpal Tunnel Syndrome</th>
<th>Ergonomics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• M Q Birkbeck 1975</td>
<td>• E M Smith 1977</td>
</tr>
<tr>
<td>• Survey of 658 patients with EMG(+) CTS</td>
<td>• 8 cadaver specimens</td>
</tr>
<tr>
<td>• 401/516 who worked were exposed to light, highly repetitive activity</td>
<td>• Pressure in carpal tunnel would increase when tension was applied to the FDP tendons of 2nd and 3rd fingers</td>
</tr>
<tr>
<td>• No control group</td>
<td>• T J Armstrong 1979</td>
</tr>
<tr>
<td></td>
<td>• Case-control study of 18 women with a clinical history of CTS and 18 women who performed the same jobs but did not have CTS</td>
</tr>
<tr>
<td></td>
<td>• Found that use of forceful exertions, particularly with deviated wrists, and pinch hand positions, were associated with CTS</td>
</tr>
</tbody>
</table>

**Social Change**
Hormel Strike Austin, Minnesota 1985

**Popular Press**
Toledo Blade – December 24, 1989
Medical Awareness (Rempel, et al. JAMA 1992)

Computer and CTS

New Technology
PC Sales

Psychosocial Factors

Insurance Acceptance

Ergonomics Standard


http://jeremyreimer.com/m-item.jsp?i=137
Government Action

• The ergonomic program standard became a final rule on November 14, 2000, and went into effect on January 16, 2001.
• Congress acted under authority of the Congressional Review Act of 1996.
• President Bush signed a joint resolution of Congress disapproving OSHA’s ergonomics standard and, at the same time, pledging to find a solution to ergonomic-related problems affecting the nation’s workforce.

Carpal Tunnel Syndrome

• Work-relatedness controversial
  • Gerr, Ann Rev Public Health 1991
  • Szabo, Clin Orthop 1998
• Closely related to health habits
• Flawed measures of exposure
  • Gerr, J Occup Med, 1992
• Prevalence same in general population whether people perform repetitive activities or not
  • Atroshi, JAMA 1999

Computer as CTS Risk Factor

• ~ 30% hand paresthesias (Stevens et al, 2001)
• ~ 3-5% confirmed median neuropathy (Stevens 2001, Andersen 2003, Atroshi 2007)
• No association with keyboard (Andersen 2003, Atroshi 2007)

Incidence of CTS in Rochester, MN
(Stevens et al, 1988)

<table>
<thead>
<tr>
<th>Year</th>
<th>Incidence Rate (per 100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981-1985</td>
<td>20</td>
</tr>
<tr>
<td>1986-1990</td>
<td>25</td>
</tr>
<tr>
<td>1991-1995</td>
<td>30</td>
</tr>
</tbody>
</table>

Minnesota
Wisconsin
Iowa

Olmsted County Demographics 2010

• Total = 146,446
  • Women = 51% (74,069)
  • Men = 49% (72,377)
• Employed = 88,553
  • Women = 55% (48,860)
  • Men = 45% (39,693)

Incidence of CTS in Olmsted County, MN

• Rochester 1961-1980 (Stevens et al, 1988)
  • 1,016 patients (798 women, 218 men)
  • 78.5% were women
  • Overall annual incidence 99/100,000 p-y
  • Women 125 to 175/100,000 p-y
  • Men 31 to 63/100,000 p-y
  • EMG 39% (1961-1965)
    61% (1976-1980)
• Possible causes
  • Increased awareness among physicians
  • Opening of the orthopedic hand clinic in 1967
  • Introduction of median palmar NCS 1977
Comparison of Incidence Studies Adjusted to US 2000 Pop.

<table>
<thead>
<tr>
<th>Time period</th>
<th>Women n</th>
<th>Rate</th>
<th>Men n</th>
<th>Rate</th>
<th>Both sexes n</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rochester</td>
<td>798</td>
<td>172</td>
<td>218</td>
<td>61</td>
<td>1016</td>
<td>118</td>
</tr>
<tr>
<td>MESA</td>
<td>219</td>
<td>461</td>
<td>180</td>
<td>353</td>
<td>399</td>
<td>377</td>
</tr>
<tr>
<td>Sienna</td>
<td>2504</td>
<td>426</td>
<td>638</td>
<td>104</td>
<td>3142</td>
<td>269</td>
</tr>
<tr>
<td>Canterbury</td>
<td>4255</td>
<td>118</td>
<td>1950</td>
<td>60</td>
<td>6245</td>
<td>90</td>
</tr>
<tr>
<td>U.K.</td>
<td>16,344</td>
<td>192</td>
<td>6514</td>
<td>78</td>
<td>22,858</td>
<td>136</td>
</tr>
<tr>
<td>Netherlands</td>
<td>87</td>
<td>240</td>
<td>26</td>
<td>77</td>
<td>113</td>
<td>162</td>
</tr>
<tr>
<td>2001</td>
<td>511</td>
<td>326</td>
<td>161</td>
<td>105</td>
<td>672</td>
<td>219</td>
</tr>
</tbody>
</table>

Possible Explanations

- True rise in incidence
- Change in diagnostic testing (EMG)
- Different case definitions and reporting sources
- Different exposure to risk factors
  - Non-occupational
  - Occupational
- Changing attitudes


- Idiopathic
- Female gender
- Wrist configuration
- Trauma (wrist fx)
- Hormonal agents
- Pregnancy
- Osteoarthritis
- Diabetes mellitus
- Obesity
- Tenosynovitis
- Thyroid disorders
- Inflammatory arthritis
- Advanced age


- Repetition
- High force
- Wrist posture
- Direct pressure
- Vibration
- (Keyboard and mouse use?)

Specific Aims

- Assess trends in CTS incidence, surgical treatment, and work-related lost time using resources of the REP and data from the MN Department of Labor and Industry
- Identify factors which might explain any changes with time
- Hypothesis – There has been a true increase in the incidence of diagnosed CTS over time

Verification of Diagnosis

- Use consensus criteria recommended for population-based epidemiologic studies (Rempel et al, 1998)
Random sample of administratively determined CTS cases

- N=194
- Excluded n=38

Classic/probable CTS

- Numbnes, tingling, burning, or pain in at least 2 of digits 1, 2, or 3 (includes all fingers if no other symptoms to suggest peripheral neuropathy)
- n=131
- Documentation of symptoms being aggravated by at least one of the following: Sleep, sustained hand or arm positioning, or repetitive actions of the hand?
- Yes
- Location of finger symptoms specified?
- Possible CTS

- Numbnes, tingling, burning, or pain in at least 1 of digits 1, 2, or 3
- n=25
- Documentation of symptoms being aggravated by at least one of the following: Sleep, sustained hand or arm positioning, or repetitive actions of the hand?
- Yes
- n=92

EMG performed?

- n=54
- n=16

Positive?

- n=16
- n=6

Verification of Diagnosis (N=194)

- 131 (67%) – classic/probable CTS
- 25 (13%) – possible CTS
- 156 (80%) – meet symptom criteria for CTS
- 38 (20%) – no finger symptoms recorded
- 113 (58%) – had an EMG
  - Similar to end of last study
  - 86% positive for classic/probable
  - 70% positive for possible

Population Trends Over Time

- CTS Diagnosis
- CTR Operation
- WR-CTS


- Women
- Men
- Both Sexes


Average neurophysiological severity (on the Canterbury scale) of new cases of carpal tunnel syndrome detected each year, male and female.
Plot of mean neurophysiological severity, on the Canterbury scale, of carpal tunnel syndrome against age for men and women (1991-2001).

Distribution of cases of carpal tunnel syndrome by Canterbury neurophysiological grade for men and women.

WR-CTS by Age Group

Age, Gender and Severity
- WA State Workers’ Compensation 1990-1994
  - Age at Filing
    - < 35 = 40%
    - 35-44 = 34%
    - ≥ 45 = 25%
  - F:M = 1.2:1
  - CTR = 64%

Young, Women=Men, High Severity

Incidence of Type 2 DM Compared to CTS in Olmsted County, MN

Summary
- Incidence increased dramatically in the 1980s, particularly in younger people
- Younger people present with less severe disease
- Elderly present with more severe disease and are more likely to have surgery
- The trend corresponded to an increase in work-related CTS
- Population incidence continued to increase throughout the study period
- Work-related CTS increased early and declined significantly in the latter part of the study, particularly in women – Why?
Specific Aims

• Compare trends in work-related non-traumatic (soft tissue) wrist injuries to WR-CTS 1986-2010
• Compare gender differences in incident WR-CTS by industry group
• Hypothesis – The epidemic was the result of soft tissue injuries being called CTS and increased WR-CTS in certain industries

Rate of Carpal Tunnel Syndrome Cases with Lost Work-Time Filed with Workers' Compensation per 100,000 Workers Covered by the Minnesota Workers' Compensation System, 2000-2011

http://lehd.ces.census.gov/applications/qwi_online/

Rate of Carpal Tunnel Syndrome Cases with Lost Work-Time Filed with Workers' Compensation per 100,000 Workers Covered by the Minnesota Workers' Compensation System, 2000-2011

http://www.health.state.mn.us/divs/hpcd/deec/health/indicators/carpal-tunnel.html

WR-CTS in Olmsted County 1986-2010

Healthcare & Education  Leisure & Hospitality  Information, Financial, Professional & Business

http://lehd.ces.census.gov/applications/qwi_online/

Generalizability

• From 1986 to 1993 there was an over-representation of women with respect to cumulative trauma disorders of the upper extremity (Brogmus, 1996)
  • A shift to service industry work does not seem to explain the increase
  • More women in the work force and increased awareness may be related
Problems With Workers Compensation Administrative Data

• Must be unable to work for 3 consecutive days
• Unpleasant experiences (Ochsner et al, 1998)
  - Employers
  - Health care
• Filters (Azaroff et al, 2002)
  - Worker perceives work relatedness of illness or injury
  - Worker perceives desirability of reporting to supervisor
  - Supervisor perceives a legitimate work-related problem
  - Supervisor allows restricted work or treatment
  - Supervisor records injury in OSHA log
  - Log is sampled by BLS survey
• Stigmatization (Anthony et al, 2008)

Concern about the concept of “work-related CTS”

• Due to the stigma associated with these conditions, could we be hurting the people that we are trying to help?
• Does the lack of detailed exposure information explain the CTS epidemic that was seen in the general population?

Summary

• WR-CTS epidemic in late 1980s and early 1990s included a disproportionate increase in young and middle-aged women across most industry groups
• The decline in WR-CTS is similarly disproportionate in women and is different than the increases in women and men in the general population
• Misclassification does not appear to explain the decrease - what about underreporting or changing beliefs?

Specific Aims

• Conduct a cross-sectional survey of medical transcriptionists, who work primarily with a computer to assess:
  - The degree to which personal/lifestyle factors, amount of computer use, history of symptom treatment, medical conditions, perceived stress and job satisfaction are associated with disability

Results

• Response rate 251/314 (80% response)
• 210/251 eligible for analysis
  - 41 respondents <1 yr current position
• CTS diagnosis 18/210 (8.6%)
  - Treated under WC 5/18
• 92% felt that keyboarding was one of the causes of CTS

Strengths of Population Based Epidemiologic Studies

• Capture the full spectrum of disease severity vs workers compensation administrative data
• Capture the people who don’t want to report a work injury or who have a work injury that is accommodated to avoid lost work time
• The data captures sociological changes
Weaknesses of Population Based Epidemiologic Studies

• Large numbers don’t usually allow for detailed chart review to confirm diagnostic criteria
• Can’t get detailed estimates of non-medical exposures
• People may not seek medical care

Further Studies

• Population survey
  • Care by non-medical providers
  • Beliefs
  • Identify specific jobs
• Link survey results to the medical record linkage system

Korea – The Next Epidemic

• http://www.arirang.co.kr/News/News_View.asp?nseq=151474

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Questions?

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REFERENCES


The changing nature of office work: effects on repetitive strain injuries


Sillanpaa J, Huikko S, Nyberg M, Kivi P, Laippala P, Uitti J. Effect of work with visual display units


Marcus M, Gerr F. Upper extremity musculoskeletal symptoms among female office workers:

Gelfman R, Beebe TJ, Amadio PC, Larson DR, Basford JR. Correlates of Upper Extremity Disability

Rosenman KD, Kalush A, Reilly MJ, Gardiner JC, Reeves M, Luo Z. How much work-related injury

Leibson C, Williamson DF, Melton LJ, 3rd, Palumbo PJ, Smith SA, Ransom JE, Schilling PL,

Gerr, F, Letz, R. Risk Factors for Carpal Tunnel Syndrome in Industry: Blaming the Victim? J Occup


Warr P, Cook, J., Wall, T. Scales for the measurement of some work attitudes and aspects of

Boz C, Ozmenoglu M, Altunayoglu V, Velioglu S, Alioglu Z. Individual risk factors for carpal tunnel

Kouyoumdjian JA, Zanetta DM, Morita MP. Evaluation of age, body mass index, and wrist index as

Karpitskaya Y, Novak CB, Mackinnon SE. Prevalence of smoking, obesity, diabetes mellitus, and

Solomon DH, Katz JN, Bohn R, Mogun H, Avorn J. Nonoccupational risk factors for carpal tunnel

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