Method to protect surgical team from harmful gases during transurethral surgery?

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Introduction

Benign prostatic hyperplasia (BPH)

• One of the most common diseases of aging men
  Greater than 50% at 60

• One half of all men who have a histologic diagnosis have moderate to severe LUTS

• Transurethral resection of the prostate (TURP) - gold standard

• TUR-surgery produce harmful gases

• Roehrborn, C. G. and McConnell, J. D. “Etiology, pathophysiology, epidemiology and natural history of benign prostatic hyperplasia”. In Campbell's Urology. chapt 38, pp 1297-1330, 2002
Surgical procedures
(cut, coagulate, vaporize or ablate tissue)

Target cells are heated to the boiling point
cell membranes ruptured

Toxic chemicals, cell particles, viruses of
various sizes and aerosol

Irrigating solution  Organ space  Operating
environment

**Figure 1.** Framework of surgical smoke produced by surgical procedures
Influence factors

Composition and amount of noxious smoke vary widely

• Nature and pathology of the treated tissue
• Surgical technique
• Energy
• Surgery
• Temperature
• Time
Effects of the chemicals

- Headache
- Irritation and soreness of the eyes, nose and throat
- Hypoxia
- Nausea and vomiting
- Sneezing
- Weakness
- Dermatitis
- Cardiovascular dysfunction
- Anxiety
- Carcinoma
Methods

Pre-operative study

- Prostate volume DRE and TRUS (B&K medical, Herlev, Denmark)
- IPSS
- QoL
- IIEF
- PSA
- Blood count, blood chemistry
- Qmax
Operative technique

• **The first period**
  - 22 F continuous-flow resectoscope and cutting loop (Karl Storz GmbH & Co, Tuttlingen, Germany)
  - The electrosurgical generator was set to 150 W for cutting and vaporization and 60 W for coagulation (AUTOCON, Karl Storz GmbH & Co, Tuttlingen, Germany)

• **The latter period**
  - HPS LASER for evaporization (60-120 W) and coagulation (AMS)
Gases produced by TUR-surgeries in bladder

Figure 2. Gases developed during TURP (A) and LASER (B) gathered in the bladder. The gas is released from the bladder to operating room when the working element is disconnected from the sheath to remove the tissues resected or irrigation.
Figure 3. The diagram of surgical smoke suction and collection during TUR-Surgery
Analysis of gases

- **Automated Purge & Trap Sampler JTD-505III** (Japan Analytical Industry Co., Ltd., Tokyo, Japan)

- **GC/MS QP 2010 plus for quantification and qualification analysis** (Shimadzu, Co., Kyoto, Japan)

- **Measured the absorbance by UV-VIS spectrophotometer at 393 nm** (Varian, Cary50, California, USA)
### Table 1. Patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>Age (Year)</th>
<th>Total prostate volume (ml)</th>
<th>Transitional prostate volume (ml)</th>
<th>Resection volume (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value (Mean ± SD)</strong></td>
<td>75.5 ±10.61</td>
<td>35 ± 16.97</td>
<td>14 ± 5.567</td>
<td>18.5 ± 10.61</td>
</tr>
</tbody>
</table>
Table 2. Qualification data of gas collected by purge and trap gas chromatography-mass spectrometry

### A: TURP

<table>
<thead>
<tr>
<th>Retention time</th>
<th>Name</th>
<th>Quality score</th>
<th>Molecular formula</th>
<th>Hazards</th>
<th>Flash point</th>
<th>Amount of gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.52</td>
<td>Isobutylene</td>
<td>97</td>
<td>Me₂C=CH₂</td>
<td>B,A</td>
<td>F</td>
<td>42335.87 ± 23522.43</td>
</tr>
<tr>
<td>3.58</td>
<td>1-pentene</td>
<td>85</td>
<td>PrCH=CH₂</td>
<td>B</td>
<td>F++</td>
<td>4115.46 ± 2390.73</td>
</tr>
<tr>
<td>2.11</td>
<td>Propylene</td>
<td>97</td>
<td>MeCH=CH₂</td>
<td>A</td>
<td>F+</td>
<td>203.41 ± 279.33</td>
</tr>
<tr>
<td>6.48</td>
<td>1,3-butadiene</td>
<td>97</td>
<td>H₂C=CHCH=CH₂</td>
<td>D</td>
<td>F++</td>
<td>38.87 ± 32.02</td>
</tr>
<tr>
<td>2.27</td>
<td>Ethylacetylene</td>
<td>94</td>
<td>EtC≡CH</td>
<td>A</td>
<td>F</td>
<td>34.66 ± 42.15</td>
</tr>
<tr>
<td>3.48</td>
<td>1,4-pentadiene</td>
<td>85</td>
<td>H₂C=CHCH₂CH=CH₂</td>
<td>C</td>
<td>F+</td>
<td>15.88 ± 14.90</td>
</tr>
<tr>
<td>3.79</td>
<td>Acrylonitrile</td>
<td>98</td>
<td>NCCH=CH₂</td>
<td>D</td>
<td>F++</td>
<td>ND</td>
</tr>
</tbody>
</table>

### B: HPS LASER

<table>
<thead>
<tr>
<th>Retention time</th>
<th>Name</th>
<th>Quality score</th>
<th>Molecular formula</th>
<th>Hazards</th>
<th>Flash point</th>
<th>Amount of gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.52</td>
<td>Isobutylene</td>
<td>97</td>
<td>Me₂C=CH₂</td>
<td>B,A</td>
<td>F</td>
<td>5220.91 ± 2717.31</td>
</tr>
<tr>
<td>3.58</td>
<td>1-pentene</td>
<td>85</td>
<td>PrCH=CH₂</td>
<td>B</td>
<td>F++</td>
<td>ND</td>
</tr>
<tr>
<td>2.11</td>
<td>Propylene</td>
<td>97</td>
<td>MeCH=CH₂</td>
<td>A</td>
<td>F+</td>
<td>21.28 ± 2.31</td>
</tr>
<tr>
<td>6.48</td>
<td>1,3-butadiene</td>
<td>97</td>
<td>H₂C=CHCH=CH₂</td>
<td>D</td>
<td>F++</td>
<td>ND</td>
</tr>
<tr>
<td>2.27</td>
<td>Ethylacetylene</td>
<td>94</td>
<td>EtC≡CH</td>
<td>A</td>
<td>F</td>
<td>ND</td>
</tr>
<tr>
<td>3.48</td>
<td>1,4-pentadiene</td>
<td>85</td>
<td>H₂C=CHCH₂CH=CH₂</td>
<td>C</td>
<td>F+</td>
<td>48.20 ± 4.65</td>
</tr>
<tr>
<td>5.30</td>
<td>Acrylonitrile</td>
<td>98</td>
<td>NCCH=CH₂</td>
<td>D</td>
<td>F++</td>
<td>ND</td>
</tr>
</tbody>
</table>

A = central nervous system depression; B = skin, eye, and respiratory irritant; C = toxic to skin and eye; D = human carcinogen; F++ = extremely flammable; S = stable (n = 12). * Notices from OSHA or ACGIH.
Figure 4. Concentration of chemicals produced during TUR-Surgeres
Conclusions

• The gas is released from the bladder to the operating room when the working element is disconnected from the sheath to remove the tissues resected or continuous irrigation.

• All chemical is very dangerous, 1,3-butadiene specially acts as a carcinogen.

• 1,3-butadiene and 1-pentene react with oxygen rapidly, and are extremely flammable and can induce explosion in deteriorated condition.

• HPS LASER also produces plume but very small amount than TURP.

• Surgical smoke produced by electrosurgery and laser ablation which has smaller particulate than plume can easily pass through the mask.

• We need continuous irrigation and a new evacuation system in operation room.
It is not enough or convenient to filter the toxic gases!

Figure 5. Kinds of mask
We have to prepare the gas evacuation system!

Figure 5. Closed gas evacuation system
Thank you for your attention!