Monitoring cortical electrical activity in anesthesia for obese patient

Gabriel M. Gurman, M.D.
Division of Anesthesiology
Soroka Medical Center and Faculty of Health Sciences, Ben Gurion University

Beer Sheva, Israel

gurman@bgumail.bgu.ac.il
OBESITY

Three thousands years ago:
Those naturally very fat are more reliable to sudden death than the thin (Hippocrates)

Today:
GLOBESITY
Some demographic data on obesity

- 1.7 billions people all over the world are obese or overweight
- USA- 1999/2000:
  *60% of all women and 28% of all men were considered overweight
- USA 2002- 110,000 bariatric surgical procedures
- In 83% of cases –nonalcoholic obese hepatosteatosis
A new classification of obesity

According to the body mass index (BMI):

- 26-29 - overweight
- 30-39 - obese
- 40-49 - morbid obese
- 50-59 - superobese
- > 60 - supersuperoese
A new entity: OBESE SUPINE DEATH SYNDROME (OSDS)!!

The following changes are typical for OSDS

<table>
<thead>
<tr>
<th>Increase in:</th>
<th>Decrease in:</th>
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</thead>
<tbody>
<tr>
<td>*oxygen consumption</td>
<td>*PaO2</td>
</tr>
<tr>
<td>*work of breathing</td>
<td>*FRC</td>
</tr>
<tr>
<td>*cardiac output</td>
<td>*Chest compliance</td>
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<tr>
<td>*pulmonary artery pressure</td>
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</tbody>
</table>
Today obesity is considered part of......

METABOLIC SYNDROME

* hyperglycemia with insulin resistance
* arterial hypertension
* central/visceral obesity
* dyslipidemia:
  * high triglycerides
  * low high-density lipids (HDL)
What do you think, in general, about the difficulties in establishing the proper dose of an anesthetic agent for an obese patient?

Some say: very simple, we are experienced!

Other specialists would add: depends on the patients

But the skeptics will always remark that nobody, absolutely nobody can be sure that he/she administered the proper dose in every case !!!
Here are two very important statements:

Clinical signs, such as blood pressure or heart rate are not always reliable parameters in deciding the adequacy of general anesthesia goals (pharmacological hypnosis, amnesia, analgesia).

Particular clinical conditions demand special precautions in order to avoid unwanted episodes of superficial anesthesia.
Clinical conditions with a high risk of superficial anesthesia

<table>
<thead>
<tr>
<th>Clinical condition</th>
<th>Possible explanations</th>
</tr>
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<tbody>
<tr>
<td><strong>The patient</strong></td>
<td>*fear of instability                     *Uncertainty of dosage</td>
</tr>
<tr>
<td>*ASA 4 or 5</td>
<td>*drugs effect wearing off</td>
</tr>
<tr>
<td>*MORBID OBESITY</td>
<td>*any single anesthetic might produce instability</td>
</tr>
<tr>
<td>*Difficult or prolonged intubation</td>
<td>*fear to affect fetus and uterine tonus</td>
</tr>
<tr>
<td>*Hemodynamic instability</td>
<td></td>
</tr>
<tr>
<td>*Obstetrical patient</td>
<td></td>
</tr>
<tr>
<td><strong>Technique and equipment</strong></td>
<td>*non-use of volatiles                            *patient alert but paralyzed</td>
</tr>
<tr>
<td>*TIVA</td>
<td>*volatile not administered</td>
</tr>
<tr>
<td>*Excessive muscle relaxants</td>
<td>*especially when associated with one of the above conditions</td>
</tr>
<tr>
<td>*vaporizer failure</td>
<td></td>
</tr>
<tr>
<td>*no premedication</td>
<td></td>
</tr>
</tbody>
</table>
Obesity and anesthetic drugs - where is a problem?
Obesity and anesthetic drugs

• Confused recommendations for using
  * Ideal body weight (IBW)
  * Lean body mass (LBM)
  * Total body weight (TBW)

• Adipose tissue acts a reservoir for many anesthetic drugs and they empty slowly, delaying recovery

• Lipophilic anesthetic drugs significantly increase their volume of distribution (VD) in obese patients
Here is a very interesting table, to be taken into consideration

<table>
<thead>
<tr>
<th>Ideal body weight (IBW)</th>
<th>Total body weight (TBW)</th>
<th>Lean body mass (LBM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remifentanil (?)</td>
<td>Propofol for maintenance</td>
<td>Remifentanil (?)</td>
</tr>
<tr>
<td>Propofol for induction</td>
<td>Thiopental</td>
<td></td>
</tr>
<tr>
<td>Vecuronium</td>
<td>Midazolam</td>
<td></td>
</tr>
<tr>
<td>Sufentany for maintenance</td>
<td>Suxamethonium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Atracurium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fentanyl</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sufentany for maintenance</td>
<td></td>
</tr>
</tbody>
</table>
Obesity and anesthetic drugs (2)

- Hepatic function is affected by obesity (hepatic steatosis, fatty changes, in 75% of obese patients - Ramsey-Stewart, Obese Surg 1993;3:157)

- On the other way, renal clearance in obese patient is enhanced, because of the increase in renal blood flow - Marik et al. Chest 1998;113:492
Seven obese and eight normal weighted patients, compared for thiopental metabolism

- When offered free hand, the anesthesiologist administered significantly less thiopental per Kg in obese patients (3.9 mg vs 5.1, p < .02)
- Elimination half life was significantly longer in obese patients (28 vs 6.3 hrs p < .001)
Diazepam terminal half life in 17 obese and 17 non-obese patients

- 95 vs 40 hours (p < 0.001)
The results?

• No clear guidelines, no recommendations regarding the dose regimen

• *Bennett et al.* Pharmacotherapy 1982;2:50- tremendous variations in the postoperative regimen for morphine, between 17 to 175 mg in the first 36 hours!!
The results?

- Servin, Anesthesiology 1993;78:657
  An original formula for calculating propofol dosage:
  Corrected weight = ideal weight + (0.4 x excess weight)
  This formula avoided drug accumulation in eight morbid obese patients

- The authors:
  - the proposed formula is empiric and not supported by the pharmacokinetic data

- Using the proposed formula MIGHT jeopardize the hemodynamic stability
If so, what could be the practical conclusion?
Erstad, 2004

There is no substitute for patient monitoring based on established clinical end points when dosing medication in the morbidly obese patient……

What end points ?!
What can be done ?!

The answer seems to be clear:

USE COMPUTERIZED ELECTROENCEPHALOGRAM, THE BEST EXPRESSION OF THE ELECTRICAL CORTICAL ACTIVITY
Spectral edge frequency

- A result of the Fourier Fast Transformation, a mathematical analysis of power spectrum
- Defined as the frequency in which 90% or 95% of the area of the wave’s histogram is below it
- Uses two symmetric channels, usually temporo-parietal, with one neutral electrode
- A range of 8 to 12 Hz is considered compatible with adequate clinical general anesthesia
How did we use Spectral Edge Frequency (SEF) in clinical anesthesia?
A multi center study (1991-1993) using an original matrix, based on the possible connection between EEG and BP

- 600 cases, all general anesthesia, 6 centers, 5 Germans and one Israeli
- Anesthetic regimen based on:
  * on line spectral edge frequency (SEF)
  * blood pressure, measured every 5 minutes
- The hypothesis: a SEF-BP correlation will make the anesthetic guidance much more effective than each of them used separately
- The aim: to reduce the intra-operative cardiovascular variability
The relationship between SEF and BP worked in more than 75% of cases.

The SEF-BP matrix ((Gurman 1994))

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>ideal</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>E</td>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>

- **SEF > 12 Hz**
  - Too superficial anesthesia

- **SEF 8 – 12 Hz**
  - SEF < 8 Hz

- **SEF < 8 Hz**
  - Too deep anesthesia

BP norm
What about the bispectral index?
BIS Algorithm Development

Raw EEG

Visual Inspection/Artifact Rejection

Bispectrum

Synchronization

Power Spectrum

Feature Extraction

Using Extensive Databases, Select Features that Correlate Best with Clinical Endpoints

Combine Features to Produce Bispectral Index
Figure 8. Detection of a malfunctioning infusion pump by the BIS. The graph shows changes in three parameters over time: BIS (top line), on the left axis, mean blood pressure (middle line), and heart rate (bottom line), both on the right axis. During this surgical procedure propofol was used as the primary hypnotic agent. Note how the BIS provided a good indication of the interruption in the propofol infusion and subsequent response to bolus doses, whereas blood pressure and heart rate did not.
Is BIS the solution to assessment of adequacy of anesthesia?

**YES**

- a reliable scale from 0 to 100, less than 50 → very few cases of awareness
- predicts consciousness, close to 100%, mostly during “light” anesthesia

**NO**

- controversial data regarding implicit memory
- some case reports of explicit memory under BIS
- use of opioids may disturb the results
- different drugs have a different influence on BIS
  
  *(Anesth Analg 1995;80:780)*
One would expect a lot of data regarding administration of anesthesia, guided by a CNS direct parameter.

SURPRISE!!
The literature is very scarce in this direction!
36 obese patients randomized to receive either desflurane, propofol or isoflurane as maintenance of anesthesia for laparoscopic gastroplasty

BIS used for “equipotent dosage”

Recovery parameters studied
Results

- **Time to extubation:**
  - *6 min for desflurane*
  - *13 min for propofol*
  - *12 min for isoflurane*

- **Best SpO2, patient mobility at PACU best after desflurane**

- **Sedation less evident after desflurane after 30 and 120 minutes**

- **Desflurane advantages persisted for at least 2 hrs after surgery**
Paventi, Minerva Anestesiologica
2002;68:651

- 40 morbid obese patients for laparoscopic cholecystectomy
- 1\textsuperscript{st} group: sevoflurane titrated by end-tidal concentration
- 2\textsuperscript{nd} group: sevo+ remifentanil titrated according to BIS values
- Results (the sevo-remi group):
  * shorter awakening time
  * shorter extubation time
  * quicker postop orientation
MORBID OBESITY AND SPECTRAL EDGE FREQUENCY IN……

Beer Sheva, Israel
- 71 morbid obese patients, scheduled for laparoscopic gastric banding
- BMI > 35
- SEF continuously monitored, but screen kept hidden
- Cutting point: SEF > 80% of maintenance time “in range” (normal range: 8-12 Hz)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>SEF 8-12 Hz &gt; 80% of time, n=38</th>
<th>SEF 8-12 Hz &lt; 80% of time, n=33</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS at admission</td>
<td>6.3</td>
<td>6.9</td>
<td>0.005</td>
</tr>
<tr>
<td>VAS RR 30 minutes</td>
<td>5.5</td>
<td>6.1</td>
<td>0.05</td>
</tr>
<tr>
<td>VAS RR 60 minutes</td>
<td>4.7</td>
<td>6.6</td>
<td>0.06</td>
</tr>
<tr>
<td>VAS RR discharge</td>
<td>3.8</td>
<td>4.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Lag time to 1st dose of MO – minutes</td>
<td>11.9</td>
<td>7.4</td>
<td>0.03</td>
</tr>
<tr>
<td>Total dose MO in RR</td>
<td>3.94 mg</td>
<td>6.1 mg</td>
<td>0.02</td>
</tr>
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</table>

Note: The patients with a longer SEF 8-12 Hz received more isoflurane (according to the end-tidal concentration)
These results imply that, by using a computerized EEG parameter for anesthetizing morbid obese patients, one can obtain a significant decrease in the postoperative need for opiates. Good enough!!
By the way......

A recent editorial from Scandinavia

Hankala AY: Will enough isoflurane during surgery replace morphine after surgery?  
*Acta Anaesth Scand*  
2003;47:785

It seems that we under-anesthetize morbid obese patients.  
Too light anesthesia might expose patients to severe postoperative pain.
But this is not the end of the story......

Because we found a very important additional fact
Comparing three groups of patients monitorized by SEF during general anesthesia

<table>
<thead>
<tr>
<th>Group of patients</th>
<th>Nr of patients in each group</th>
<th>% of total maintenance time in which SEF remained between 8-13 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthopedic surgery, normal BMI</td>
<td>39</td>
<td>87</td>
</tr>
<tr>
<td>Laparoscopic cholecystectomy, BMI &lt; 28</td>
<td>40</td>
<td>83</td>
</tr>
<tr>
<td>Gastric banding for morbid obesity</td>
<td>71</td>
<td></td>
</tr>
</tbody>
</table>
In other words, the natural trend of the average anesthesiologist is to underestimate the anesthetic needs of the morbid obese patient!
CONCLUSIONS
Thoughts to take home...

- Anesthesia of the morbid obese is not simple.....
- Beside the well known difficulties one can add that of TITRATING ANESTHETIC DOSAGE
- The literature lacks precise guidelines in this direction, so the dangers of underdosage (awareness) or overdosage (hemodynamic consequences, delay of recovery) are to be taken into consideration
If so, it seems very recommendable to use a EEG computerized parameter in order to guide the anesthetic drugs titration in morbid obese
Summarizing this recommendation, we would like to offer a final table.
The possible benefit of EEG monitoring during general anesthesia for morbid obese patient

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevention of overdosing, quicker recovery, less anesthetic drugs used</td>
<td>Because of lack of precise guidelines regarding dosage</td>
</tr>
<tr>
<td>Better hemodynamic stability</td>
<td>Not studied, yet, in obese patients</td>
</tr>
<tr>
<td>Better postoperative analgesia</td>
<td>Large doses of opiates could lead to respiratory depression</td>
</tr>
<tr>
<td>Prevention of awareness</td>
<td>Last studies show a significant reduction of awareness in normal weight patients, so why not for the obese as well?</td>
</tr>
</tbody>
</table>
With such understanding, we can not only hope to better use our pharmacologic arsenal for the morbid obese, but also to understand how to prevent the frequent intra- and post-operative complications in this high risk group of patients.