Obesity in Pregnancy
An Imaging Challenge

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Objectives

Impact of obesity in pregnancy

- Population statistics
- Increased maternal and fetal risks

Quality of patient care

- Limitations US
- Tips & Tricks
- Ergonomic issues

Future
What is Obesity?

Fundamental energy imbalance between calories consumed / expended

Complex interaction genetics, environment and metabolic factors
What is obesity?

<table>
<thead>
<tr>
<th>BMI (Body Mass Index)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-25</td>
<td>Normal weight</td>
</tr>
<tr>
<td>25-30</td>
<td>Overweight</td>
</tr>
<tr>
<td>30-35</td>
<td>Class 1 Obese</td>
</tr>
<tr>
<td>35-40</td>
<td>Class 11 Obese</td>
</tr>
<tr>
<td>≥ 50</td>
<td>Class 111 Morbidly Obese</td>
</tr>
<tr>
<td>≥ 50</td>
<td>Super Obesity</td>
</tr>
</tbody>
</table>

BMI (Body Mass Index) = weight (kg) / height (m)²

Practical perspective ~ 90 kg/200lb
How is Obesity Affecting our Population?

USA

- > 50% women reproductive age group are overweight or obese with ~ 30% frankly obese

Greatest growth in higher classes of obesity


Obesity & Pregnancy

- Obesity is the **commonest clinical risk** in obstetric practice

  - ~1/3 deaths occur in obese gravida

How is Obesity Affecting our Population? (G8 countries)

- Attributed to maternal obesity each year estimate
  - 3,168 stillbirths
  - 3,610 infant deaths
  - 570,449 cesarean deliveries
  - 1,105 neural tube defects
  - 780 cases of congenital heart defects
  - 135,258 cases of preeclampsia.

France Germany Italy Japan UK US Canada Russia
Pregnancy and Obesity
Maternal & Fetal Risks
Maternal Risks

- Obesity is an independent risk factor for adverse maternal obstetrical outcome

- Pre-existing significant health challenges
  - Hypertension, diabetes, VTE, cardiorespiratory disease & sleep apnea contribute to surgical and anesthetic risk

- Increased C-section rates & peri-operative complications

<table>
<thead>
<tr>
<th>Maternal Risks</th>
<th>Odds Ratios</th>
<th>Class 1</th>
<th>Class 11/111</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre eclampsia</td>
<td>1.4-2.0</td>
<td></td>
<td>2.4-3.3</td>
</tr>
<tr>
<td>Hypertension</td>
<td>6</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>DM</td>
<td>2.3</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Gestational DM</td>
<td>1.6-2.6</td>
<td></td>
<td>3.6-4.0</td>
</tr>
<tr>
<td>Cardiac</td>
<td>1.4-3.4</td>
<td></td>
<td>3.4-5.6</td>
</tr>
<tr>
<td>VTE (DVT)</td>
<td>2.7</td>
<td></td>
<td>4.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Odds Ratio</th>
<th>Class 1</th>
<th>Class 11/111</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anomalies</td>
<td>1.8</td>
<td>3.3</td>
</tr>
<tr>
<td>Macrosomia</td>
<td>1.6-2.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Birth trauma</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>(shoulder dystocia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stillbirth</td>
<td>1.1</td>
<td>1.4 – 2.0-x</td>
</tr>
<tr>
<td>NICU</td>
<td>1.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Hypoglycemia, hyperbilirubinemia

Case

- 27 yo G1P0 transferred for 3rd trimester care
- Normoglycemic
- “heavy” since childhood as were her family members & partner
Case

- EFW 36 wks ~5000g
  11 lbs

10 cm to fetal surface
Decision Deliver @ 38 wks
Based EFW prediction & BMI

Chose elective C-section
- Avoid risk shoulder dystocia & birth trauma
- Aware rapid emergent C-section may technically impossible
- Chose epidural
  - Difficult to secure safe AW, concern barotrauma due higher ventilation settings.

4 epidural attempts
Operating Room Challenges

To Lift or not Lift

- > 350 lbs the pannus may
  > 100-150 lbs.
- Limited ability secure back with tape – if retract onto chest may compromise breathing thus harness the pannus to hook in ceiling
- Total time = 5 hours

- Risk C-section in BMI ≥ 40 ~ 50%
  - failed TOL or concerns
- Special equipment such as bariatric beds (> 500 lbs), BP cuffs, lifting equipment, extra-long catheters,...
“Good” Outcome?

- 6100 gm !!
  (13.5 lb)
Maternal Obesity and EFW

- Define macrosomia ~ 4 - 5,000 gm
  - Risk shoulder dystocia
    - 5% @ 4000 gm
    - 30% @ 4500 gm

- May counsel early induction or C-section on basis of EFW
  - Accuracy of EFW in women with normal BMI within 7 to 13%
  - Accuracy of EFW in morbidly obese is unclear
Maternal Obesity and EFW

◆ EFW at upper extremes of BW associated errors exceeding 10% BW
  ➣ BW > 4500 gm
  ➣ < 50% fetuses within 10% EFW

■ Need refinements of EFW formulae
  ◆ Unrecognized IUGR patterns
  ◆ Customize growth curves

6100 gm or 13.5 lbs vs 5,000 gm or 11 lbs
Implications of Maternal & Neonatal Obesity

Maternal Obesity

- Gain > weight during pregnancy
- Less success in losing weight after pregnancy

Lifelong increased maternal morbidity & mortality
Effects of Maternal Obesity on Next Generation

- Infants obese mother
  - 24% children obese @ 4 years vs 9% healthy BMI

- Macrosomic infants
  - 9x increased risk adult obesity & development of metabolic syndrome

- Fetus with an accelerated growth pattern
  - 5x more likely to become obese adults

Environmental influences with high caloric intake but low energy expenditure lifestyles

Genetic / Psychological susceptibility to obesity

Future hyperphagia/overeating
Impaired glucose tolerance

Obesity Vicious Cycle

Life in the Womb will be written on your Tomb

Study: Pregnant Obesity
Published April 19, 2011 | NewsCore

Mother's diet during pregnancy alters baby's DNA

By James Gallagher
Health reporter, BBC News

A mother's diet during pregnancy can affect her child, researchers.

Researchers from the United States said the study, to be published next week, provides "compelling scientific evidence for the link between pregnant women's diet to childhood obesity."

"We have shown for the first time that susceptibility to obesity cannot simply be attributed to our genes, but can be triggered by influences on the baby in the womb, including what the mother ate," said Southampton University Professor Keith Godfrey, who led the research.

How diet, genes and pregnancy programme poor health
Tuesday April 19th, 2011

A woman's poor diet during pregnancy may cause changes to the DNA that will mean her child piling on fat later in life, researchers have revealed.

A woman does not have to be overweight to put her child at risk - all she has to do is to eat the wrong foods, scientists say.

Researchers at Southampton University worked with others in New Zealand and Singapore on the project.

They say diet during pregnancy can trigger "epigenetic" changes - which alter the way genes function.

The decade long study found that women with a poor diet were 50% more likely to have obese children, sometimes before they even knew they were pregnant. The scientists concluded that women should be given specific nutritional advice during pregnancy to help prevent childhood obesity.
Clear genetic etiology in some morbidly obese

- Pradi-Willli (deletion chromosome 15) – uncontrollable hunger
- > 30 known such “obesity susceptible” loci

Diagnosis permit early intervention & treatment

Why your DNA Isn’t Your Destiny

- Shift in thinking
  - Darwin - evolutionary changes take place over many generations
Why Your DNA Isn’t Your Destiny

- Now know
  - Bypass natural evolution and pass along new traits within single generation by changing methyl groups
    - Act to turn gene on/off or alter the degree it is expressed
    - These changes may be multigenerational
  - Epigenetics: Study methyl chemical tags sit on top of genes
    - DNA is the hardware (genome)
    - Methyl groups are the software (epigenome)
Environmental influences with high caloric intake but low energy expenditure lifestyles

Genetic / Psychological susceptibility to obesity

EPIGENETIC
High sensitivity during pregnancy to nutritional environment

Obesity Vicious Cycle

Evolution in thinking

- Obesity is a vicious cycle
  - Alteration of fetal neural programs due epigenetic
  - Can predispose your kids even preconception
    - Can be multigenerational adverse effects
    - Some genotypes are more susceptible than others

- Good news
  - Opportunity to manipulate epigenetic markers
  - Only long-term success in obesity treatment is bariatric surgery

NEJM 2010;363:2339
Maternal Obesity & Ultrasound

The Challenge
Imaging Tips – Patient Position

- Not Supine – Risk aorto-caval compression
  - Oblique, decubitus or semi-recumbent
    - Improve pulmonary mechanics and avoid hypoxemic/hypotension
Imaging Tips

The closer the better

Scan umbilicus - thinnest part of abdominal wall

Scan above or below the pannus

Lateral decubitus displace the pannus
Imaging Tips
Know your equipment!

- Not just choosing the right transducer
  - Narrow sector width - permit increase scan lines per cm
  - Harmonics, spatial compound imaging
  - Post processing tools

Magic button – automatic presets for larger patients
Imaging Tips

Know your equipment!

- Harmonics
- Focal Zone
- Compound
Optimal Timing of the Anatomic Survey

- In the **obese category** probably wait > 20 weeks
  - Minimal or no improvement with delay, prolong exam
  - BMI being best predictor of SUV
    - Decreased DR rates anomalies range from 20-50%

*Lantz et al 2004; Wolfe et al; Schwarzler et al; Wong et al; Thornburg et al 2009*
Obesity and US Technology

Manufacturers developing:

- New convex 1mHz probes
- Beam forming algorithms to better model overweight patients
- Tissue aberration correction programs to adjust for speed of sound in adipose tissue
## Obesity and the Routine Fetal Anatomic Survey

*Is there really an issue?*

<table>
<thead>
<tr>
<th></th>
<th>Controls</th>
<th>&gt; 30 BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed anatomy</td>
<td>97.5%</td>
<td>74%</td>
</tr>
<tr>
<td>Repeat scan required</td>
<td>2.5%</td>
<td>26%</td>
</tr>
<tr>
<td><strong>Indication recall</strong></td>
<td>Heart, spine</td>
<td>Heart, Facial profile, spine</td>
</tr>
</tbody>
</table>

*Maxwell, Glanc J Mat Fetal Neonatal Med 2010*
Why Persist?

- Obese gravida undergo additional scans with limited success
  
  - Increase risk birth defects as increase BMI
    - Mechanism complex/unknown
    - NTD, cardiac….
  
  - Detection rates decreased (20-50%)
    - Remains residual risk after “normal” US

Maternal Obesity & Birth Defects

- Prospective population based case control 20,248 newborns
- 11.1% malformation children of mum’s with BMI > 30
  - 4% higher than total study population
- Obesity independent risk factor
  - No change in OR’s when adjust for MA or diabetes

Obese women – special challenge

- Increased risk of birth defects but decreased detection rates
- Delay, repeat, prolong exam may not help
Role for Early Anatomic Survey (TVS)

- EAS is reliable in most patients (multiple studies)
  - Developmental perspective
    - 15-16 weeks most structures developed with exception of CNS (CC, cerebellum +/- CSP by 20 weeks)
      - > 90% CHD correctly diagnosed by 14 wks. (L. Allan)
    - Recognize residual late onset anomalies occur even after routine scan

- 1 published prospective study in obese population
## Role for EAS (TVS) in the Obese Gravida

### Advantages:
- Bypass abdominal pannus
- Excellent patient tolerance
- Use higher frequency/better resolution probe

### Limitations
- Learning curve to perform study
  - Different planes of imaging
  - Embryology – GA dependent development of organs
37 year old
G5P2A2
BMI 40 — class III (morbid obesity)

<table>
<thead>
<tr>
<th>EAS versus Routine</th>
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<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Exam TVS: 14 wk 5 days (15 wks)</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Exam TAS: 19 wk 6 days (20 wks)</td>
</tr>
</tbody>
</table>
Prospective study 15wk (TVS) vs routine 20wk

- 144 patients
- Mean BMI 41 (Class III) / Median BMI 39
- Standard OBS sheet (Normal, abnormal, NWS)

EAS @ 15 wks

- Excluding CSP completions rates ~ 70% @ 15 weeks vs 60% at 20wks.
- Improved confidence EAS (TVS) @ 15 weeks
  - Structures seen confidently vs 20 weeks 40% request repeat US with SUV in majority
Overall exam completion of all 26 anatomic components at the EAS was 14.3% and at the routine R-TAS was 61%.

- Not surprisingly the CSP and distal spine were most often not visualized.

The combined completion rate (EAS + R-TAS together) for anatomic evaluation was 90%.

- Results similar to that published by Gupta/Timor-Tritsch et al JUM 2014

Thus suggest perhaps offer routinely EAS to obese pregnant women.

Submitted – C. Maxwell, P. Glanc
Role 15 week EAS Obese Gravida

Work in Progress

- Patient acceptance
  - 23% prefer EAS vs 34% prefer routine

- Sonographer preference for EAS

- Mean scan time shorter ~ 20 min for EAS

Preliminary results promising

Submitted – C. Maxwell, P. Glanc
Ultrasound

An Occupational Hazard
How do we keep everyone happy?
Despite good ergonomic practices

- Remain key risk factors WRMSD
  - Repetitive motion
  - Forceful or awkward motions
  - Prolonged duration of pressure
  - Longer scan times
Prolonged duration of pressure, excess force required
Basic Do’s & Don’ts

- Table too high
- Chair too low
- Angle arm/shoulder abduction should be < 30 degrees
- Patient body as close to sonographers as possible
**Pinch Grip**
Use ~ 25% total grip strength

**Power Grip**
Use all hand muscles
Additional Strategies are Helpful

- Special tables - *Permit patient to get up unassisted*

- Adjustable Equipment & voice commands

- More frequent breaks & task rotation

- Enlist patient / family to help lift pannus
# Ultrasound: Occupational Hazard

- **80%** sonographers develop WRMSD
  - **Education**
  - **Ergonomic equipment**
  - **Personal responsibility for aggressively applying good ergonomic work practices at all times.**
U.S. obesity rates are increasing

- State- and national-level data (BRFSS of CDC)
  - Predict if maintain rate by 2050, ~ 100% Americans will be overweight

Latest CDC (NHAMES) data suggest stabilization

- Either success at behaviour modification or reached plateau in population who are genetically/psychologically susceptible to obesity

## Let’s Talk

- **65%** world's population live where overweight and obesity kills more people than underweight
  - Includes high-income and middle-income countries.
  - Globally, 44% of diabetes, 23% of ischaemic heart disease and 7–41% of certain cancers are attributable to overweight and obesity.

- Pregnancy is an important to intervene, in particular for women planning pregnancy
  - Highly motivated to either loose weight or gain more appropriate weight during that pregnancy.
Concluding Thoughts

- Obesity as a disease is complicated
  - Obesity is a modifiable risk for adverse fetal and maternal outcome

- Imaging obese pregnant patients is difficult
  - Consider timing of studies, new technology
  - Need new algorithms for accurate EFWs
  - Consider future role in large capacity MRIs?

- Research in epigenetics & early diagnosis and intervention is crucial to improve both maternal & fetal outcomes.
Obesity is one of the great public health challenges of the 21st century
Thank you.


- Imaging and Obesity: A Perspective During Pregnancy. C Maxwell, P Glanc. AJR 2011

Maternal Obesity in Pregnancy
Consequences for Brain Function in Offspring

- Obesity state of low-grade inflammation
- Associations with offspring ADDH & autism spectrum disorder
- Study found amniotic fluid contain differences in mRNA for 20 genes of which several impact brain sculpting