Recent developments in epidural analgesia for labour

Professor Alex T Sia  MBBS, M.Med, FAMS, MBA
Chairman of Medical Board, KK Women’s and Children’s Hospital;

Professor and Senior Associate Dean (KKH Campus),
SingHealth Duke-NUS Graduate Medical School;

Clinical Professor, School of Medicine  and
Adjunct Professor, Faculty of Engineering,
National University of Singapore
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Disclosures:
• US provisional patent application number US 61/567892. Title: ‘Variable frequency automated mandatory boluses in patient controlled epidural analgesia for labor and delivery’.
• US provisional patent application number US 61/382,945. Title: ‘A novel closed loop, double vasopressor infusion system for arterial blood pressure to improve perioperative outcome during anaesthesia. Date: 15 September 2010

• Alex T Sia serves as the scientific director of Innovfusion Pte Ltd, a technology company whose products will include pain therapy devices
GUINNESS BOOK OF RECORDS

THIS IS TO CERTIFY THAT

Kandang Kerbau Maternity Hospital is the World’s Largest with a record birth of 39,835 babies in 1966

DONALD MCFARLAN NORRIS McWHIRTER

*This certificate does not necessarily denote an entry into the Guinness Book of Records*
Labour Pain

subjective  dynamic  unpredictable

Multifactorial influences:
- Sociocultural & psychological factors
- Clinical –
  - Dysfunctional labour (Cephalopelvic disproportion, malpresentation)
  - Oxytocin augmentation
  - Macrosomia
Labour pain

Maternal and fetal physiological changes

- maternal catecholamine surge
- maternal hyperventilation
- increased oxygen consumption
- uncoordinated uterine contraction
- decreased placental perfusion
- reduced fetal oxygen delivery
- posttraumatic stress
- persistent pain
- postpartum depression
Maternal request is a sufficient indication for pain relief in labour

‘Person-centric’ Care

ACOG Committee on Obstetric Practice. Obstet Gynecol 2006
The ‘IDEAL’ ANALGESIA

- Minimise side effects / motor blockade in mothers:
  - Preserve maternal comfort
  - Ensure adequate strength to push during 2nd stage

- Safeguard wellbeing of foetus

- Seamless analgesia throughout all phases of labour

- Reduce need for interventions / top ups / interruptions

‘Prevention’
Modern neuraxial labour analgesia

Ban L. Sng, Sarah C. Kwok, and Alex T.H. Sia

Department of Women’s Anaesthesia, KK Women’s and Children’s Hospital and Duke-NUS Graduate Medical School, Singapore

Purpose of review
Neuraxial analgesia is considered the gold standard of labour analgesia as it provides the most effective method of pain relief during childbirth. In this article, we explore the recent advances in the initiation and maintenance of epidural analgesia.
PCEA

- PCEA allows parturients the autonomy to intermittently self bolus
- Flexibility to accommodate analgesic requirements
- Reduces analgesic consumption and side effects
- Improves analgesic quality and satisfaction
Patient-controlled epidural analgesia versus continuous infusion for labour analgesia: a meta-analysis

M. van der Vyver¹, S. Halpern²* and G. Joseph²

- PCEA reduced drug consumption, reduced motor blockade, epidural supplementation (n=640)

- Review of 19 studies; PCEA was found to result in
  - reduced analgesic consumption and motor block
  - reduced pain scores,
  - reduced workload,
  - increased satisfaction

vs continuous infusion and manual boluses.

Patient-Controlled Epidural Analgesia for Labor

- Background infusion
  - improved maternal analgesia and
  - reduced unscheduled clinician interventions.
- Larger bolus doses (more than 5 mL) may provide better analgesia compared with small boluses.
- High volume, dilute local anaesthetic solutions with a continuous background infusion - the most successful strategy?
Practice Guidelines for Obstetric Anesthesia

An Updated Report by the American Society of Anesthesiologists Task Force on Obstetric Anesthesia*

The literature supports greater analgesic efficacy for PCEA with a background infusion compared with PCEA without a background infusion; meta-analysis of the literature also indicates no differences in the mode of delivery or frequency of motor block

Recommendations. Patient-controlled epidural analgesia may be used to provide an effective and flexible approach for the maintenance of labor analgesia. The Task Force notes that the use of PCEA may be preferable to fixed-rate CIE for providing fewer anesthetic interventions and reduced dosages of local anesthetics. PCEA may be used with or without a background infusion.

PCEA with a background infusion improves analgesia, improves maternal satisfaction, and reduces the need for anesthetic intervention.
PCEA - Questions...

IS A BACKGROUND ‘MAINTENANCE’ CONTINUOUS INFUSION NEEDED?
ARE BOLUSES BETTER?

Slow continuous infusion (with lower injection pressures), causes drug to exit almost exclusively from the most proximal hole of multiorifice catheter: limited spread

Bolus injections, with greater injection pressures, allow drug exit from all holes of multi-orifice catheter: more spread
ARE BOLUSES BETTER?

Intermittent boluses found to produce a more uniform epidural spread than a continuous infusion

Hogan Q. Reg Anesth Pain Med 2002

Automated regular boluses for epidural analgesia: a comparison with continuous infusion

Y. Lim, A. T. H. Sia, C. Ocampo

Original Article

Automated intermittent epidural boluses improve analgesia induced by intrathecal fentanyl during labour

[L'administration automatisée de bolus intermittents améliore l'analgésie induite par du fentanyl intrathécal pendant le travail]

Sebastian M.H. Chua MMED,* Alex T.H. Sia MMED†

Regular intermittent boluses can ↑ maternal satisfaction and ↓ the incidence of breakthrough pain compared with continuous epidural infusion
Incorporation of mandatory boluses into PCEA regimens
RCT using a **dual-pump** system
• First pump administered a **PCEA**,  
• Second pump administered either programmed intermittent boluses (**PIEB**) of 6ml every 30 mins **OR** a continuous infusion (**CEI**) of 12ml/hr

**PCEA+PIEB** group:
• less bupivacaine consumption  
• similar analgesic efficacy  
• higher patient satisfaction scores
A randomized comparison of automated intermittent mandatory boluses with a basal infusion in combination with patient-controlled epidural analgesia for labor and delivery

S. Leo, C.E. Ocampo, Y. Lim, A.T. Sia
Department of Women’s Anaesthesia, KK Women’s and Children’s Hospital, Singapore

Single pump system
• syringe driver to function as a PCEA pump with the ability to deliver background automated mandatory boluses (AMB)

• Double-blind RCTs PCEA + automated mandatory boluses of 5ml every hour (vs PCEA + basal continuous infusion 5ml/hr)

• Larger proportion of patients in PCEA+AMB did not require self-bolus
  • ↓ local anaesthetic consumption
  • ↑ maternal satisfaction scores

Giorgio Capogna, MD, Michela Camorcia, MD, Silvia Stirparo, MD, and Alessio Farcomeni, PhD

**PCEA + 10 ml/h** with 0.0625% bupivacaine + 2 mcg/ml fentanyl
Programmed intermittent boluses (**PIEB**) vs continuous epidural infusion (**CEI**)

**PIEB:**
- Lower drug consumption,
- fewer PCEA boluses,
- fewer parturients requiring PCEA boluses

**Motor block:**
- Lower with PIEB (2.7% vs 34% in CEI)
  Occurred earlier; more frequent at 2nd stage with CEI

**CEI:**
- higher number of instrumental delivery (20% vs 7% with PIEB)
Intermittent Epidural Bolus Compared with Continuous Epidural Infusions for Labor Analgesia: A Systematic Review and Meta-Analysis

Ronald B. George, MD, FRCPC,* Terrence K. Allen, MBBS, FRCA,† and Ashraf S. Habib, MB, ChB, MSc, MHS, FRCA‡

- 9 RCTs, > 700 patients analysed
- Intermittent epidural bolus (vs continuous infusion)
  - reduced the amount of LA used
  - Higher maternal satisfaction
  - ? Reduced instrumental delivery (no difference in CS rate)

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**Table 1: Comparison of Intermittent Epidural Bolus (IEB) vs Continuous Epidural Infusion (CEI)**

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>IEB</th>
<th>Events</th>
<th>Total</th>
<th>CEI</th>
<th>Events</th>
<th>Total</th>
<th>Weight</th>
<th>Odds Ratio M-H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capogna 2011</td>
<td>5</td>
<td>75</td>
<td></td>
<td>14</td>
<td>70</td>
<td></td>
<td>24.1%</td>
<td>0.29 [0.10, 0.84]</td>
</tr>
<tr>
<td>Fettes 2005</td>
<td>10</td>
<td>20</td>
<td></td>
<td>10</td>
<td>20</td>
<td></td>
<td>18.3%</td>
<td>1.00 [0.29, 3.45]</td>
</tr>
<tr>
<td>Leo 2010</td>
<td>2</td>
<td>31</td>
<td></td>
<td>6</td>
<td>31</td>
<td></td>
<td>9.9%</td>
<td>0.29 [0.05, 1.55]</td>
</tr>
<tr>
<td>Lim 2005</td>
<td>3</td>
<td>30</td>
<td></td>
<td>3</td>
<td>30</td>
<td></td>
<td>9.9%</td>
<td>1.00 [0.19, 5.40]</td>
</tr>
<tr>
<td>Lim 2010</td>
<td>3</td>
<td>25</td>
<td></td>
<td>6</td>
<td>25</td>
<td></td>
<td>12.2%</td>
<td>0.43 [0.09, 1.97]</td>
</tr>
<tr>
<td>Salim 2005</td>
<td>4</td>
<td>64</td>
<td></td>
<td>2</td>
<td>63</td>
<td></td>
<td>9.3%</td>
<td>2.03 [0.36, 11.52]</td>
</tr>
<tr>
<td>Sia 2007</td>
<td>1</td>
<td>21</td>
<td></td>
<td>2</td>
<td>21</td>
<td></td>
<td>4.6%</td>
<td>0.47 [0.04, 5.68]</td>
</tr>
<tr>
<td>Wong 2006</td>
<td>3</td>
<td>63</td>
<td></td>
<td>4</td>
<td>63</td>
<td></td>
<td>11.8%</td>
<td>0.74 [0.16, 3.44]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>329</td>
<td>323</td>
<td>100.0%</td>
<td></td>
<td></td>
<td></td>
<td>0.59 [0.35, 1.00]</td>
<td></td>
</tr>
</tbody>
</table>

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**Figure 3.** Forest plot for mode of delivery (instrumental). CEI = continuous epidural infusion; IEB = intermittent epidural bolus.
The Effect of Manipulation of the Programmed Intermittent Bolus Time Interval and Injection Volume on Total Drug Use for Labor Epidural Analgesia: A Randomized Controlled Trial

Cynthia A. Wong, MD, Robert J. McCarthy, PharmD, and Bradley Hewlett, MD

<table>
<thead>
<tr>
<th>Group</th>
<th>Programmed interval (min)</th>
<th>Bolus volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5/15</td>
<td>15</td>
<td>2.5</td>
</tr>
<tr>
<td>5/30</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>10/60</td>
<td>60</td>
<td>10</td>
</tr>
</tbody>
</table>

Conclusions: Extending the programmed intermittent bolus interval and volume from 15 minutes to 60 minutes, and 2.5 mL to 10 mL, respectively, decreased bupivacaine consumption without decreasing patient comfort or satisfaction. (Anesth Analg 2011;112:904–11)

Speed of BOLUS injection, injection pressure...?
PCEA - questions...

IS A BACKGROUND ‘MAINTENANCE’ CONTINUOUS INFUSION NEEDED?
The principles of Computer-integrated PCEA (CI-PCEA)

- ‘Background maintenance doses’ (PIEB or infusion) may not be needed in early labour.
- Variable ‘background maintenance doses’ (PIEB or infusion) which are responsive to the patient’s needs may provide more efficacious analgesia.
- CI-PCEA pump ‘records the number of patient-demands over the past hour and titrates its basal infusion proportionally.’
Two-way communications between the pump and the laptop computer using RS232 serial ports.

Modified Infusion Pump (IVAC P700, Alaris, UK)

Remote Control

Laptop (IBM Thinkpad) with built-in program for computer integrated patient controlled epidural analgesia.

CI-PCEA program source code compiled in Borland Pascal language on Windows Operating Systems.
Computer-Integrated PCEA
Computer-integrated patient-controlled epidural analgesia: a preliminary study on a novel approach of providing pain relief in labour
Sia A T, Lim Y, Ocampo C E

CI-PCEA vs CONTINUOUS INFUSION (PILOT)

CIPCEA group:

(maternal complaint of pain or pressure that required supplemental epidural medications)

(10% in CI-PCEA vs 40% in CEI group, p=0.027)

=> Fewer anesthetist top-ups required

No increase in drug consumption

Similar side effects, obstetric outcomes
Comparison of computer integrated patient controlled epidural analgesia vs. conventional patient controlled epidural analgesia for pain relief in labour

Y. Lim,¹ A. T. Sia² and C. E. Ocampo³

¹ Associate Consultant, ² Head of Obstetric Anaesthesia and Senior Consultant, ³ Clinical Fellow, Department of Women’s Anaesthesia, KK Women’s and Children’s Hospital, Singapore

CI-PCEA VS DEMAND-ONLY PCEA

Mean consumption of LA was similar

- CI-PCEA group had higher ‘maternal satisfaction’ scores
- Statistically similar incidence of breakthrough pain (maternal complaint of pain or pressure that required supplemental epidural medications) (15% in CI-PCEA vs 35% in PCEA)
CI-PCEA VS PCEA + BASAL INFUSION 5ML/H

- Similar incidence of breakthrough pain
- Mean consumption of LA was similar
  (CIPCEA: 9.0mg/hr vs PCEA+BI: 9.3mg/hr)
- CIPCEA group had a higher infusion rate during 2nd stage of labour
- No difference in duration of 2nd stage or mode of delivery
- CIPCEA group had higher ‘maternal satisfaction’ scores than PCEA+BI
ADVANTAGES OF CI-PCEA

- Responsive to the dynamic and progressive nature of labour pain

- Background infusions ‘triggered’ by patient:
  - ↓ LA usage in early labour when there is less pain
  - ↑ LA usage in late labour to match patient’s needs
Breakthrough pain 3X risk

Dysfunctional labour (needing intervention)

25% success / total ratio 3X risk

5 unit BMI - 2X risk

Results: The incidence of breakthrough pain was 9.6%. Independent factors associated with incidence of breakthrough pain were duration of labor, increased maternal body mass index, and increased total local anesthetic consumption, and decreased maternal satisfaction. Breakthrough pain was also associated with decreased successful-to-total-bolus-demand ratio. The postlabor characteristics independent associated with breakthrough pain were increased duration of labor, increased total local anesthetic consumption, and decreased maternal satisfaction.

Conclusions: Low successful-to-total patient demand bolus ratio was the only factor associated with breakthrough pain who received combined spinal epidural analgesia with CPTPCEA.

Participants are 280 nulliparous women in early labor (≤ 5 cm cervical dilatation).
PCEA with

Variable frequency automated boluses (VAMB) 5 ml boluses given once, twice, thrice or four times per hour depending on the history of demands over the past hour

CI 5ml/H

VAMB

Lower incidence of breakthrough pain (5.9% vs 23.5%)

Higher patient satisfaction

Lower drug consumption (N.S. p=0.06)

No difference in maternal / neonatal adverse effects
IBM Thinkpad containing PCEA source codes

Patient demand button
Personal digital assistant (PDA) operating on Windows Mobile systems

Patient demand button

Modified infusion pump
3rd Generation CI-PCEA

IBM Notebook WIFI enabled

Modified infusion pump

Patient demand button
Proprietary Algorithm – Modulates the background dose based on patient’s demand for analgesia.

Robust Construction – Dual drive bars for rapid bolus delivery.

Rapid Bolus Delivery – Achieves an effective sensory blockade through better spread of drugs within epidural space.

External connectivity and data log – Pump data downloadable for review of medication history.

Patient Handset Accessory – Easily delivers patient controlled analgesia (PCA) boluses.

Graphical User Interface – 4.3” colour display (including vital signs) and intuitive controls enhance pump usability and patient safety.
Patient controlled analgesia with remifentanil versus epidural analgesia in labour: randomised multicentre equivalence trial

Results 1414 women were randomised, of whom 709 were allocated to patient controlled remifentanil and 705 to epidural analgesia. Baseline characteristics were comparable. Pain relief was ultimately used in 65% (447/687) in the remifentanil group and 52% (347/671) in the epidural analgesia group (relative risk 1.32, 95% confidence interval 1.18 to 1.48).

An important finding from the secondary outcome measures is the high incidence of desaturations, with oxygen saturations below 92% in 18% and below 95% in 38% of women treated with remifentanil, compared with 5% and 12% in women treated with epidural analgesia (table 6).

There were four reported respiratory depressions with <8 breaths a minute in the remifentanil group, all during administration of remifentanil. Although the difference in occurrence is not significant, probably because of the low prevalence of respiratory depression, and although there were about 25% missing values, this is a potentially life threatening side effect of remifentanil. Caregivers should be aware that serious respiratory complications can occur during administration of remifentanil (table 6).

Conclusion In women in labour, patient controlled analgesia with remifentanil is not equivalent to epidural analgesia with respect to scores on satisfaction with pain relief. Satisfaction with pain relief was significantly higher in women who were allocated to and received epidural analgesia.
Novel vital signs-controlled, patient-assisted intravenous analgesia using remifentanil for labour and delivery

Precision

Safety Mechanism
At any time, if SpO₂ < 95% or heart rate < 60 beats/min for > 15 sec → pause the pump for 5 min and reassess SpO₂ and heart rate. Upon reassessment:
• If SpO₂ > 95% and heart rate > 60 beats/min → restart the pump at the previous level
• If SpO₂ < 95% or heart rate < 60 beats/min → alert the attending anaesthetist
CI-PCEA Central Monitoring system

Central Monitoring System

Nurse Nursing Station

Alarms/Data

Electronic Patient Charts

Doctors ODM/Tablet/Phone/SMS

SpO₂
Heart Rate
Respiratory

Patient

KK Women's and Children's Hospital

SingHealth
SUMMARY

- Labour pain is an extremely subjective & constantly evolving experience
  - no ‘one-size fits all epidural!’
- **PCEA** is the gold standard for maintenance of neuraxial block;
  - moderate background ‘maintenance infusion’ of a low concentration local anaesthetic + opioids solution is useful
- **Intermittent boluses** are a useful alternative to a continuous infusion in the maintenance of neuraxial block-
  - drug sparing and may reduce instrumental delivery
- Technology driven **refinement** of ‘smart’ delivery systems to
  - improve safety, efficacy, efficiency and individualization of care
thank you!