Haemodynamic changes after spinal anaesthesia for caesarean section

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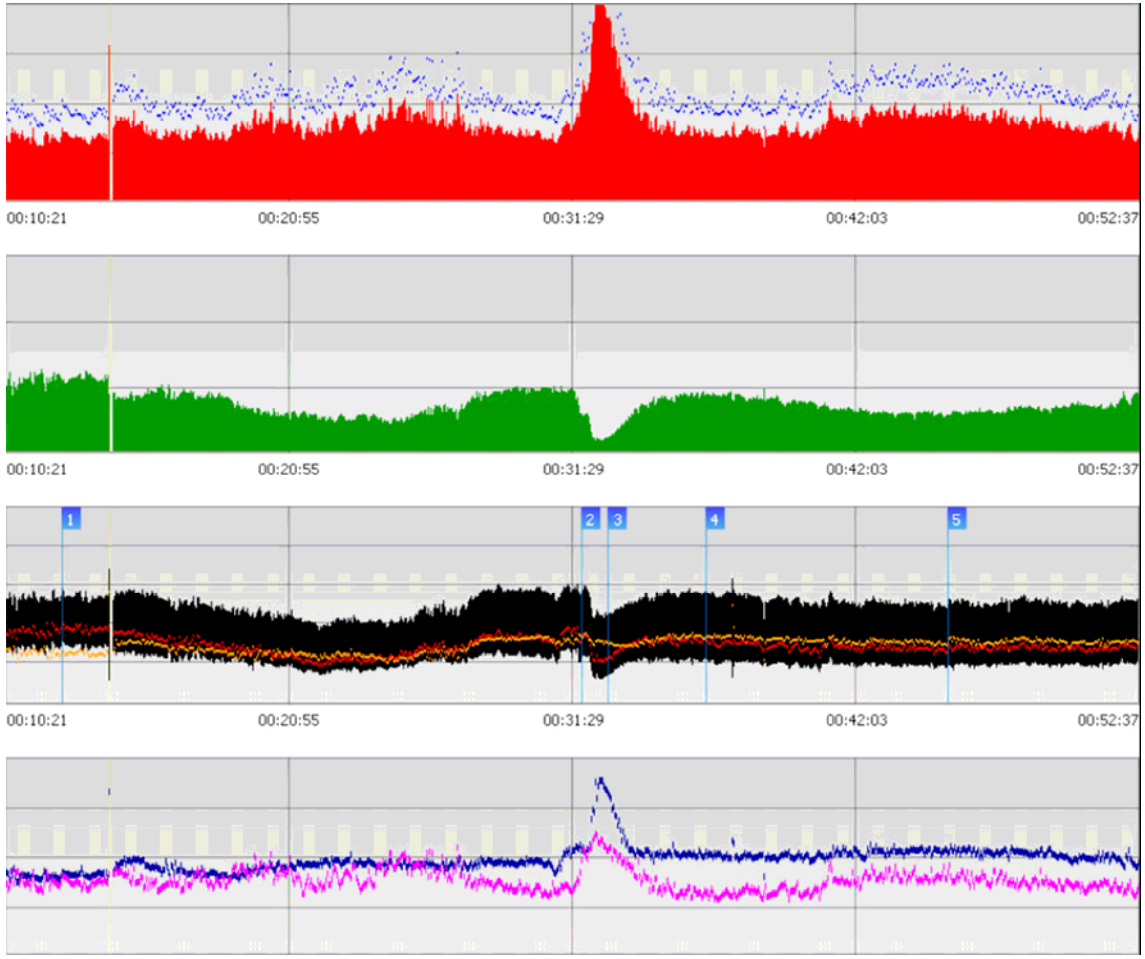


SFAI, Kalmar September 2011

No disclosure

Agenda

- History
- Haemodynamic effects in healthy pregnant
  - Spinal anaesthesia
  - Vasopressors
  - Oxytocin
- Haemodynamic monitoring in obstetric patients
  - Preeclampsia
  - Cardiac disease

Incidence of aortocaval compression pre-anaesthesia

- Early dye dilution studies
  - Lees et al, Clin Sci 1967
    - Cardiac output 12% lower in supine position
    - 2/8 had sudden bradycardia and a 50% decrease in CO
  - Ueland et al, AJOG 1968
    - Cardiac output 34% and stroke volume 44% lower in supine position

- "Supine hypotensive syndrome":
  2.5-20%, mean 8% Kinsella, Obstetrics and Gynecology 1994

During spinal anaesthesia

- Indicator dilution during spinal anaesthesia: Cardiac output improved by change to lateral position (3.5 to 6.1L/min)

  Ueland, Am J Obstet Gynecol 1968

- Umbilical venous and arterial saturation also improved by change to lateral position

  Ansari, J Obstet Gynaecol 1970

However...

- Rapid infusion of crystalloid preload relatively unsuccessful in preventing hypotension

  Rout, Anesthesiology 1999

- Crystalloid coload and colloids are better, but hypotension persists..

  Dyer, Anaes Intens Care 2004; Morgan, Anesth Analg 2001

- So, therapies based on the concept of caval compression do not prevent hypotension after spinal anaesthesia

Techniques for preventing hypotension during spinal anaesthesia for caesarean section (Review)

Cyna AM, Andrew M, Emmett RS, Middleton P, Simmons SW

- 75 studies

2006

No single intervention have been shown to eliminate the need to treat maternal hypotension during spinal anaesthesia

Prevention of Hypotension during Spinal Anesthesia for Cesarean Delivery

An Effective Technique Using Combination Phenylephrine Infusion and Crystalloid Cohydration

Ngan Kee et al. Anesthesiology **2005**

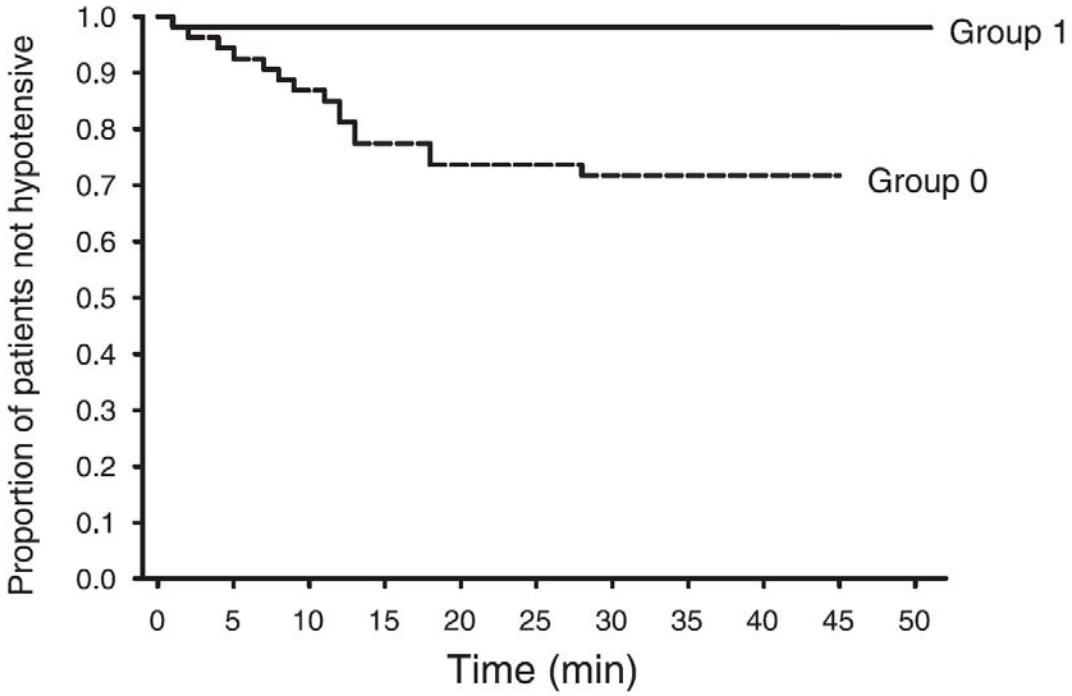


Fig. 3. Kaplan-Meier survival curves showing proportion of patients remaining not hypotensive until uterine incision. There was a significant difference between groups ($P = 0.0002$).

Problem solved?

Table 2. Hemodynamic Changes, Fluid, and Vasopressor Requirement

	Group 0	Group 1	*P* Value
Total intravenous fluid, ml	50 [40–60]	1,975 [1,609–2,010]	< 0.0001
Rate of intravenous fluid infusion, ml/min	1.7 [1.5–2.4]	63.5 [53.7–74.4]	< 0.0001
Total phenylephrine dose, μg	1,400 [1,145–1,818]	1,160 [753–1,568]	0.008
Rate of phenylephrine administration, μg/min	55.9 [46.3–63.6]	42.1 [30.4–52.3]	< 0.0001
Incidence of hypotension	15 (28.3%)	1 (1.9%)	0.0001
Minimum recorded SBP, mmHg	95 [89–106]	107 [98–110]	0.0002
Incidence of hypertension	25 (47%)	25 (47%)	1.0
Maximum recorded SBP, mmHg	139 [129–147]	140 [128–149]	0.83
Incidence of bradycardia (HR < 50 beats/min)	13 (24.5%)	9 (1.8%)	0.34
Minimum recorded HR, beats/min	53 [50–58]	58 [52–63]	0.013
Atropine required	0	0	1.0

47% hypertension in both groups

High doses of phenylephrine, median 1400µg vs 1160µg

Ngan Kee et al. Anesthesiology **2005**

What are our goals?

- Maintain baseline maternal cardiac output and blood pressure
- Maintain uterine arterial flow and pressure
- *Preserve normal physiology!*

Continuous Invasive Blood Pressure and Cardiac Output Monitoring during Cesarean Delivery

A Randomized, Double-blind Comparison of Low-dose versus *High-dose Spinal Anesthesia with Intravenous Phenylephrine or Placebo Infusion*

Langesæter et al. Anesthesiology **2008**

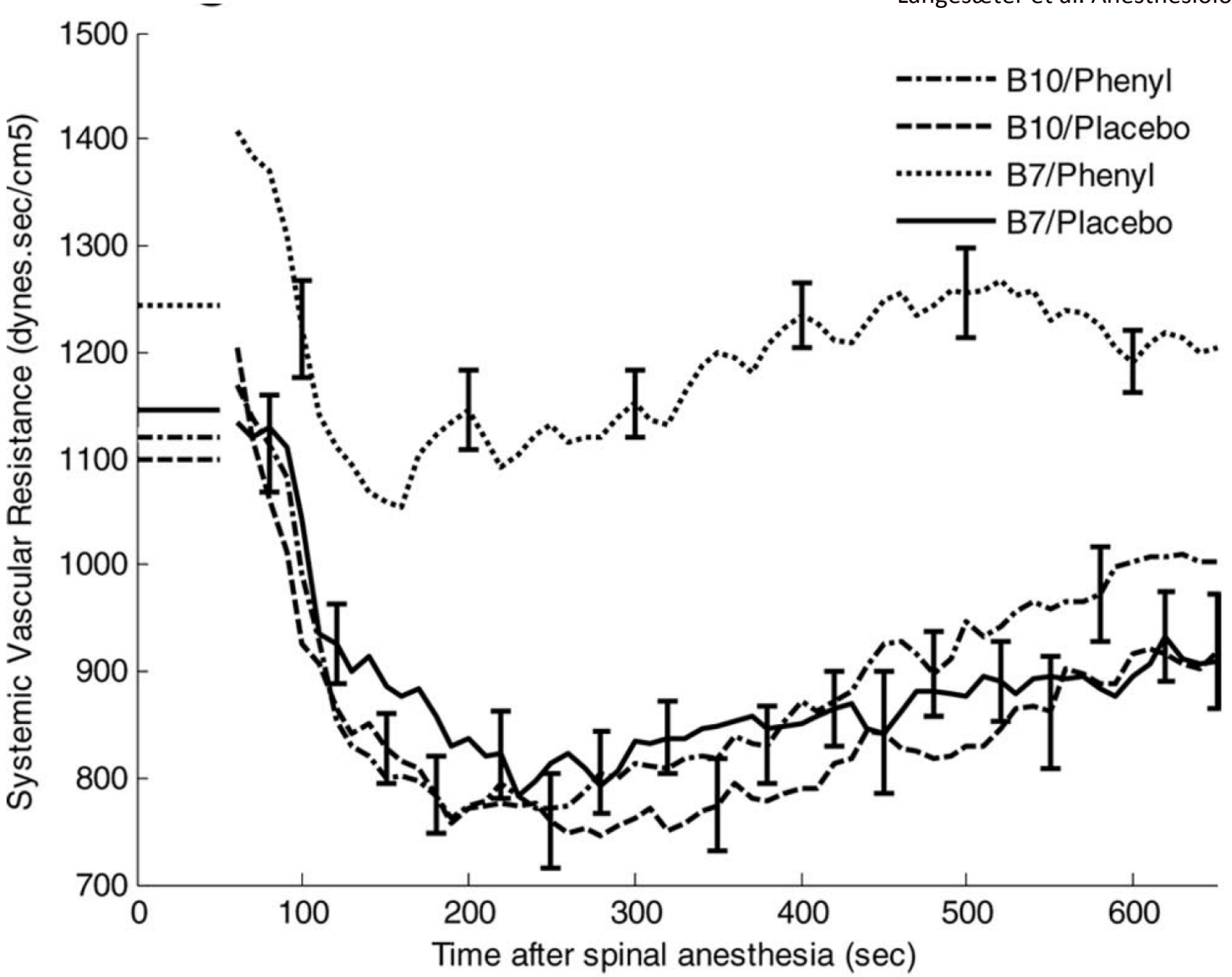
80 healthy pregnant women randomised to 4 different groups

Spinal bupivacaine plain 7 mg vs 10 mg (sufentanil 4 µg)
Phenylephrine-infusion 0.25 µg/kg/min vs placebo
Coload NaCl 0.9% 750 ml

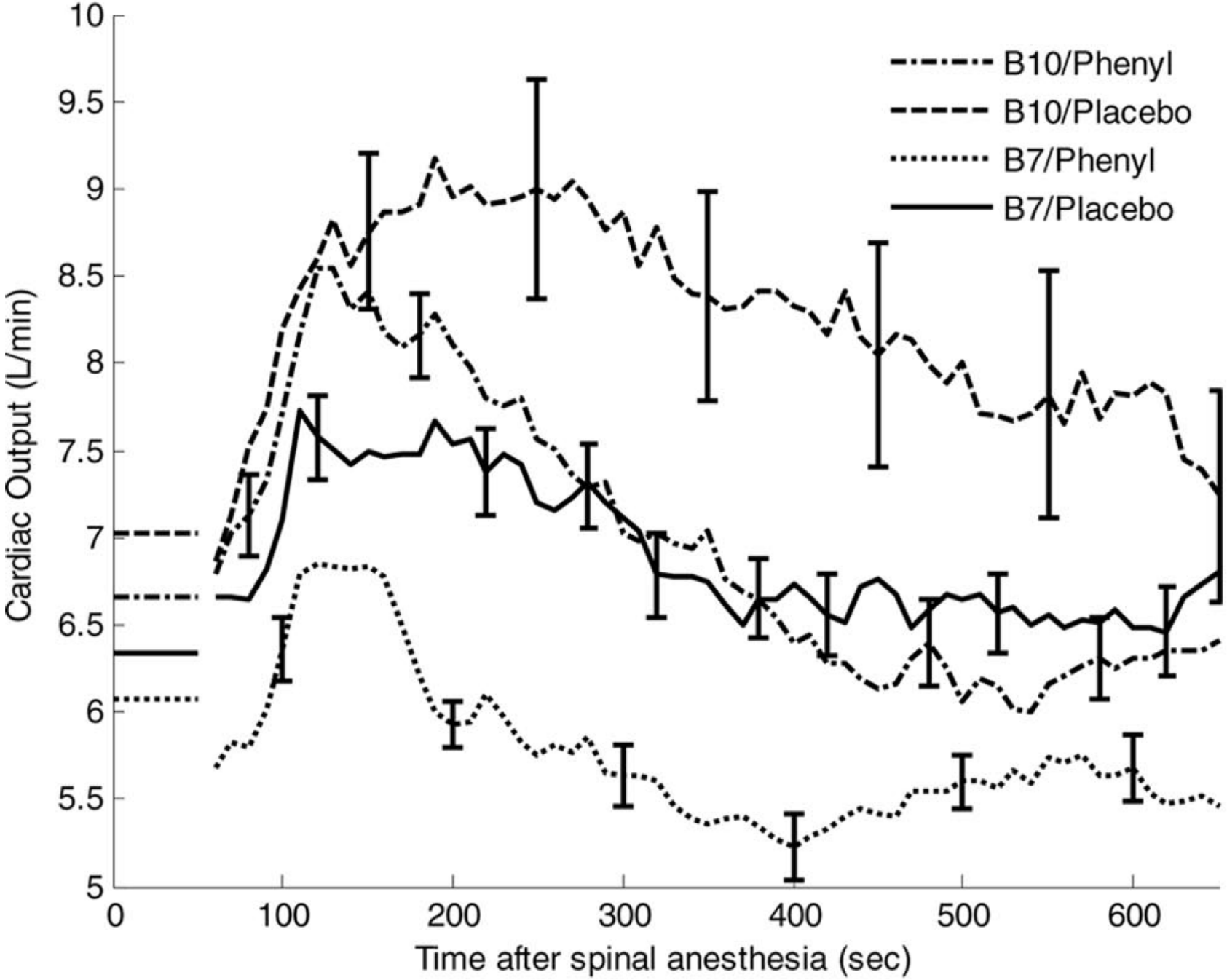
An arterial line and CO-monitoring

Main outcome: Group-differences in SAP and CO

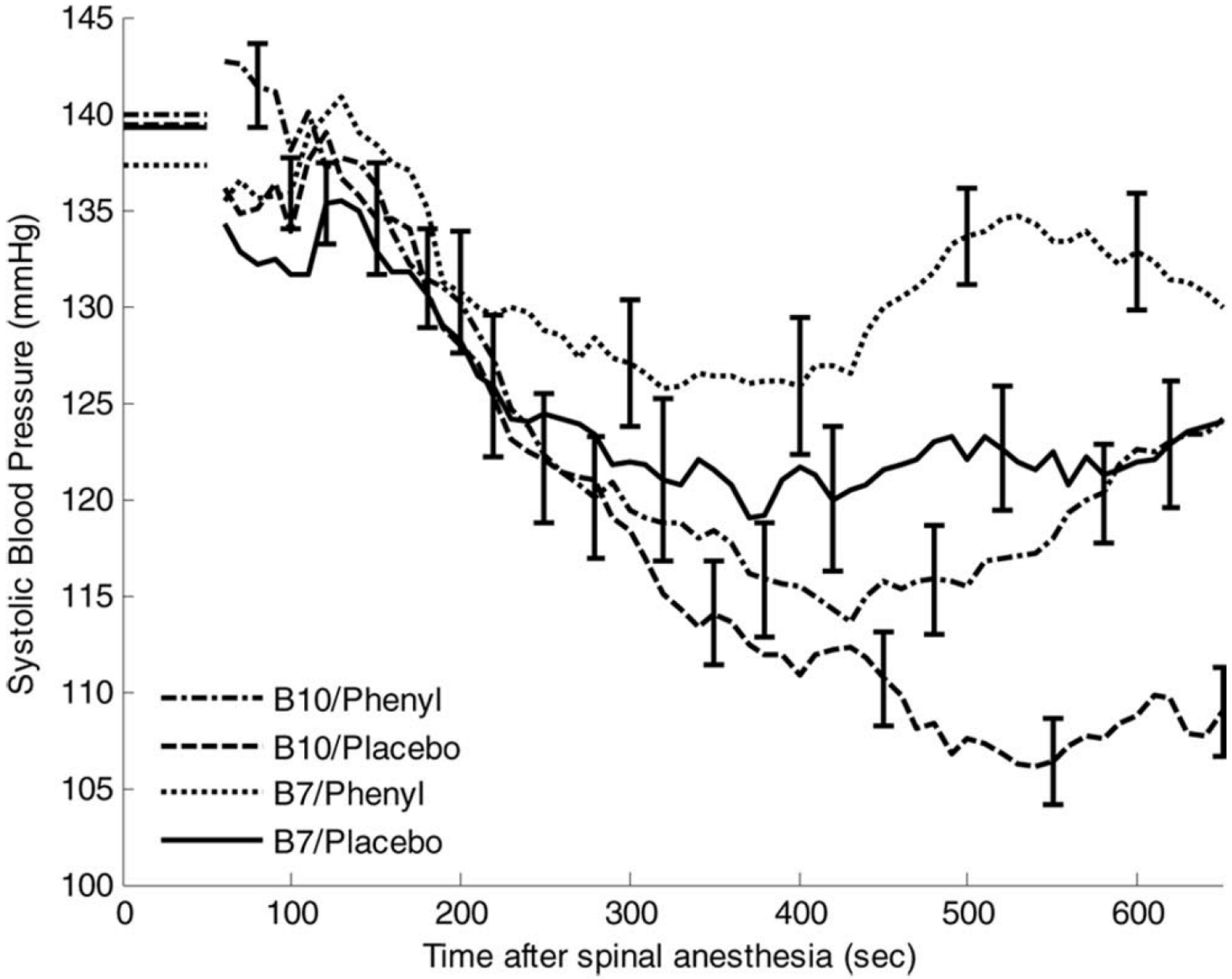
Langesæter et al. Anesthesiology **2008**



Langesæter et al. Anesthesiology **2008**



Langesæter et al. Anesthesiology **2008**



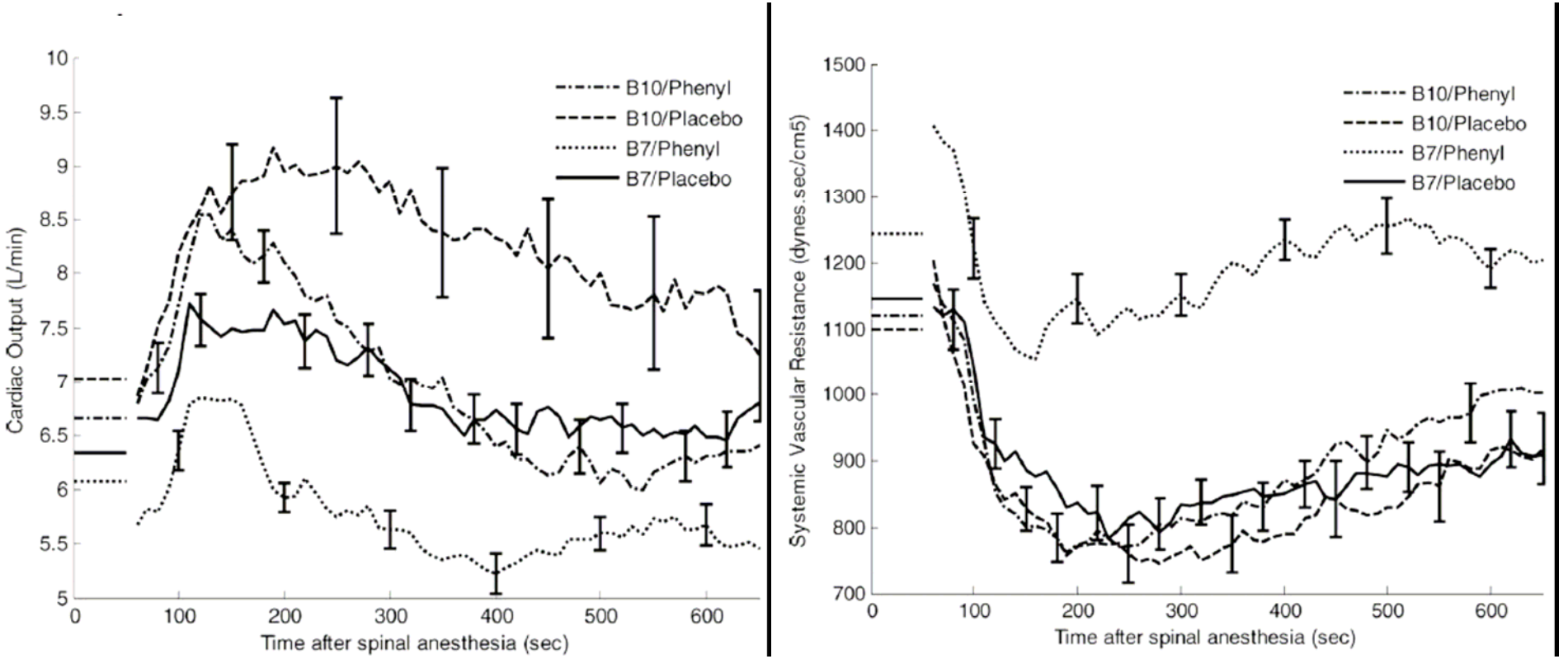
Maternal hypotension

Hypotension following neuraxial anesthesia for cesarean section (CS) is the result of several factors. Sympathectomy leads to a decrease in systemic vascular resistance, venous return, and cardiac output. The reduced cardiac output can be due to the decrease in venous return or bradycardia associated with higher blocks. These factors combined with aorto-caval compression in late pregnancy can lead to profound hypotension. Normal pregnancy may be

Reidy and Douglas, Anesth Clin **2008**,26: 75-88

What are the main haemodynamic effects of spinal anaesthesia?

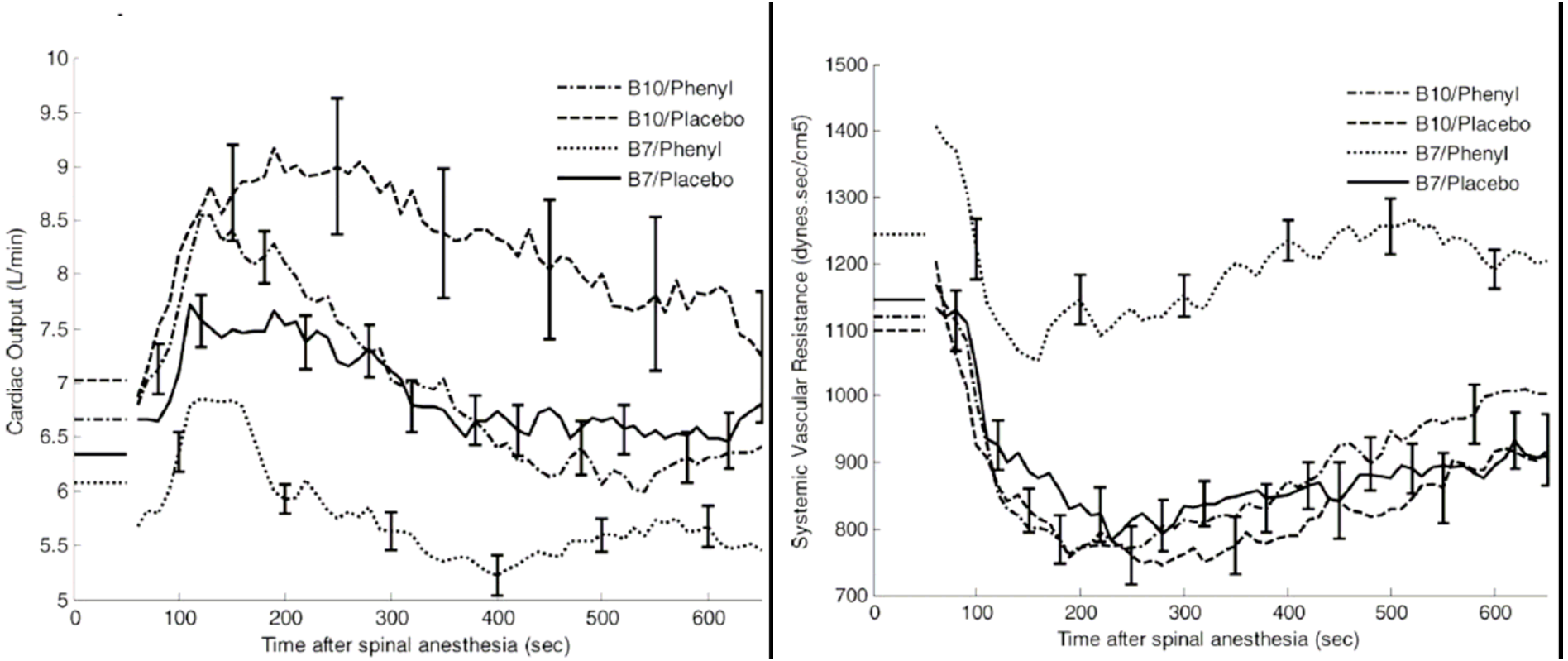
The haemodynamic effects of spinal anaesthesia in healthy pregnant women



Langesæter et al. Anesthesiology **2008**

The haemodynamic effects of spinal anaesthesia in healthy pregnant women

Give an initial bolus of phenylephrine (50µg) to prevent hypotension



Langesæter et al. Anesthesiology **2008**

Hemodynamic Effects of Ephedrine, Phenylephrine, and the Coadministration of Phenylephrine with Oxytocin during Spinal Anesthesia for Elective Cesarean Delivery

Dyer et al, Anesthesiology **2009**

When MAP had decreased by 20%

- Systemic vascular resistance 35% ⇩
- Heart rate 12% ⇧
- Stroke volume 9% ⇧
- Cardiac output 22% ⇧

Editorial I

Hypotension in obstetric spinal anaesthesia: a lesson from pre-eclampsia

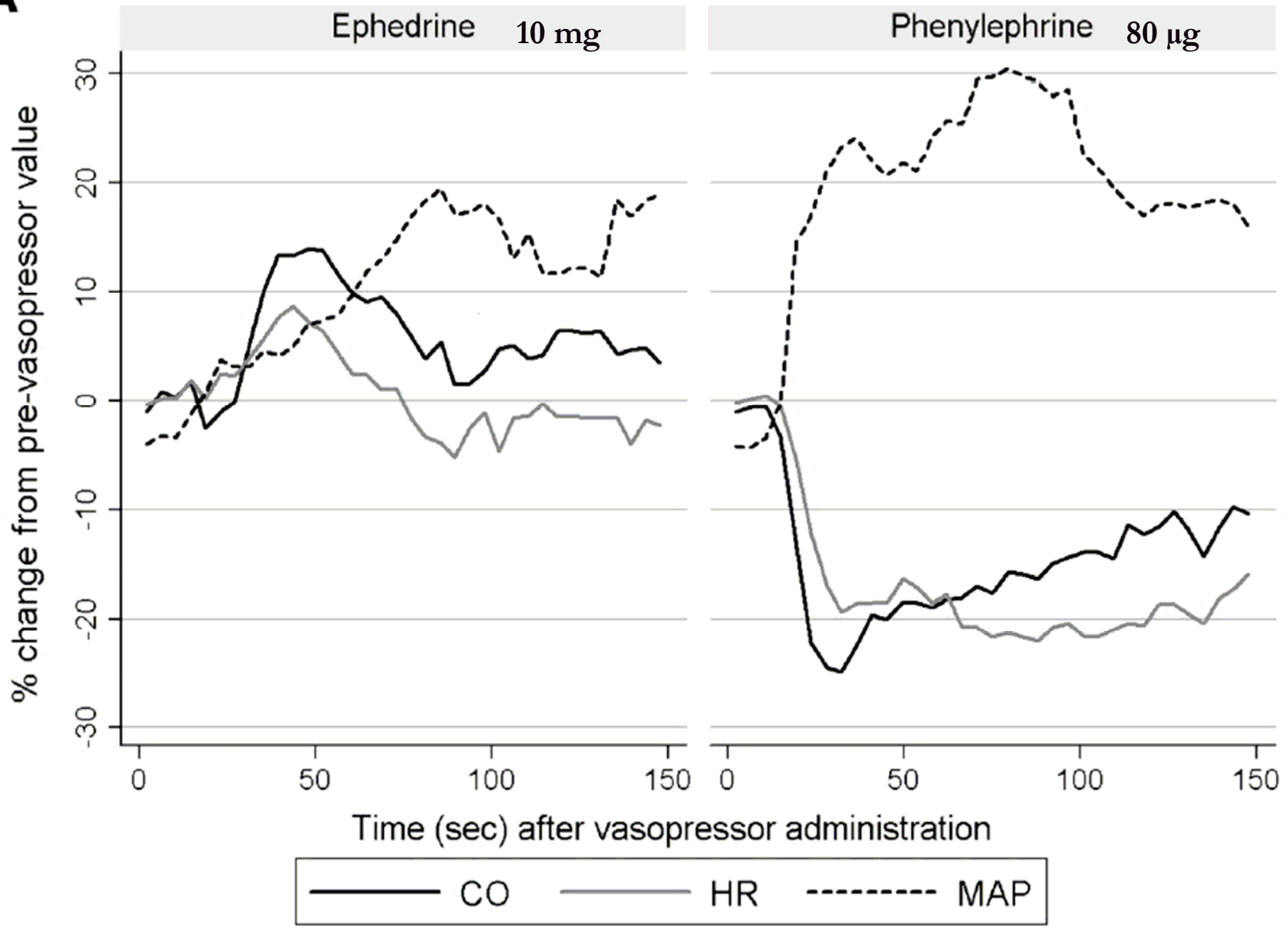
Sharwood-Smith & Drummond, BJA **2009,**

Venous return may not be the main explanation for hypotension during spinal anaesthesia for elective caesarean section

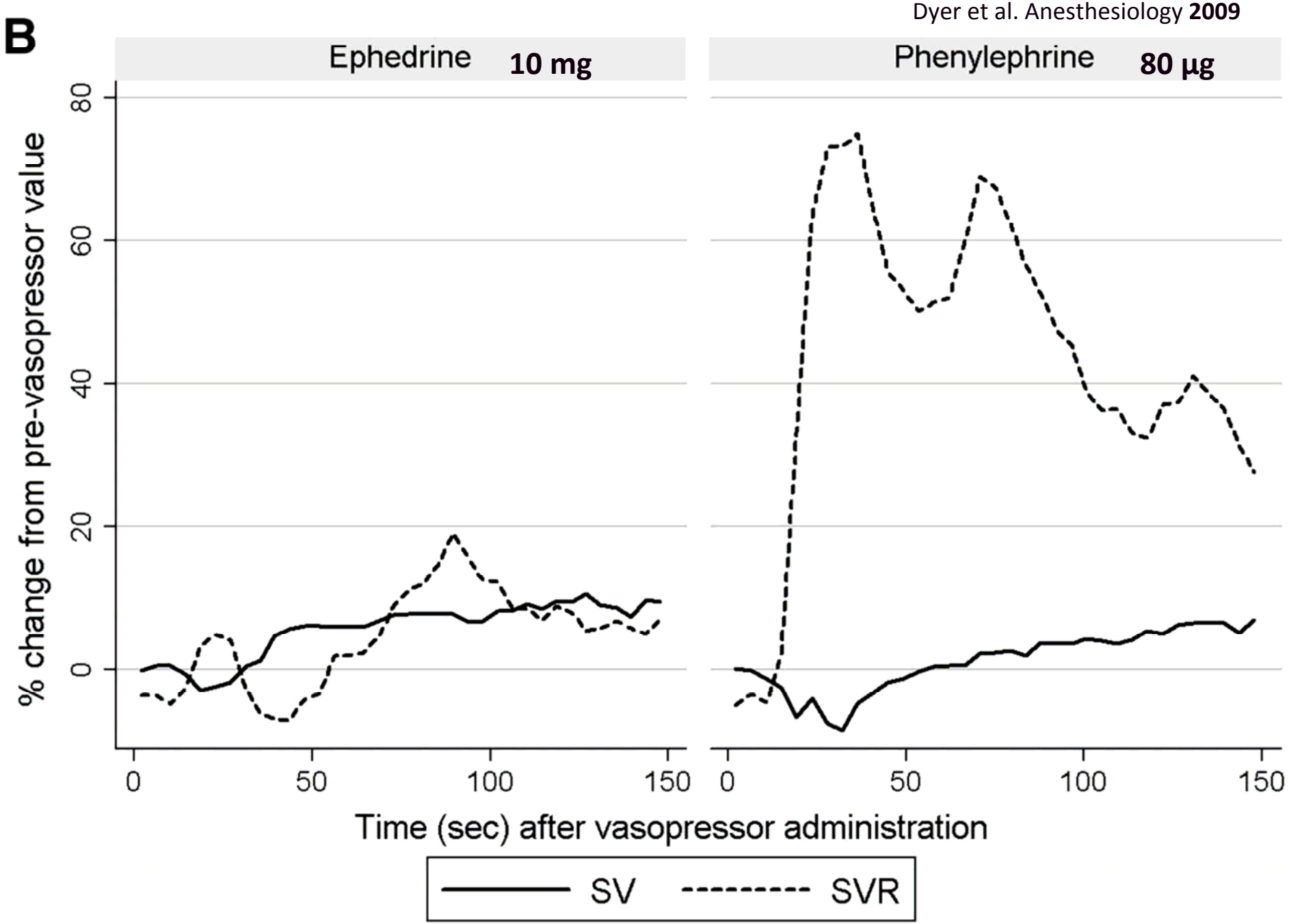
Focus on the arterial circulation

A

Dyer et al. Anesthesiology **2009**

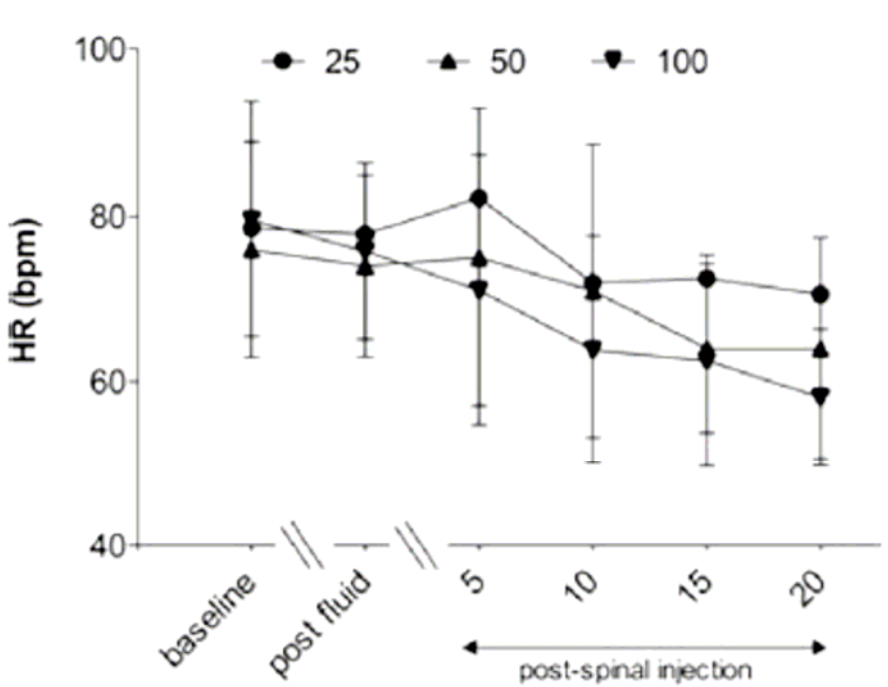


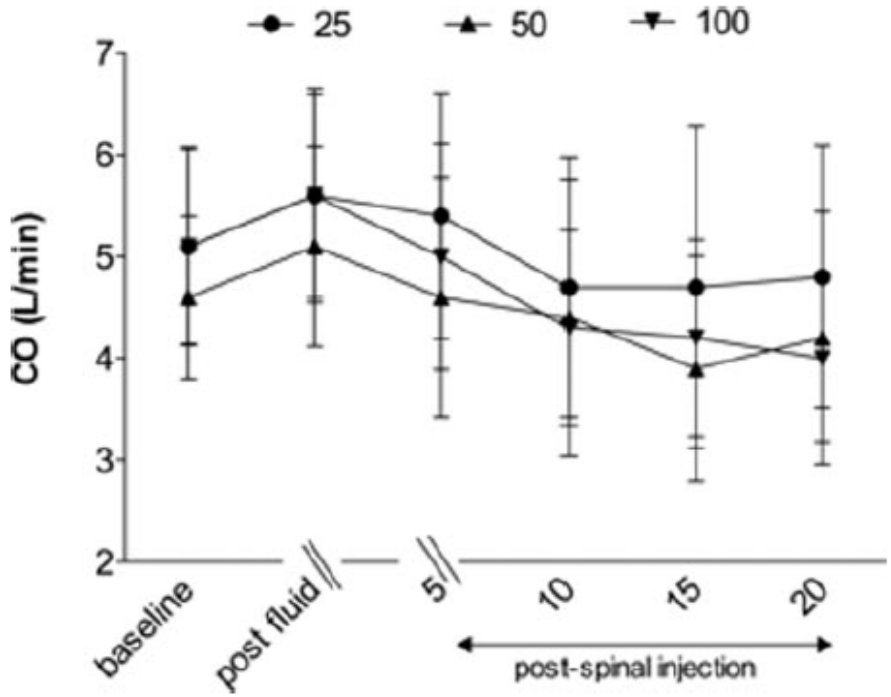
Dyer et al. Anesthesiology **2009**



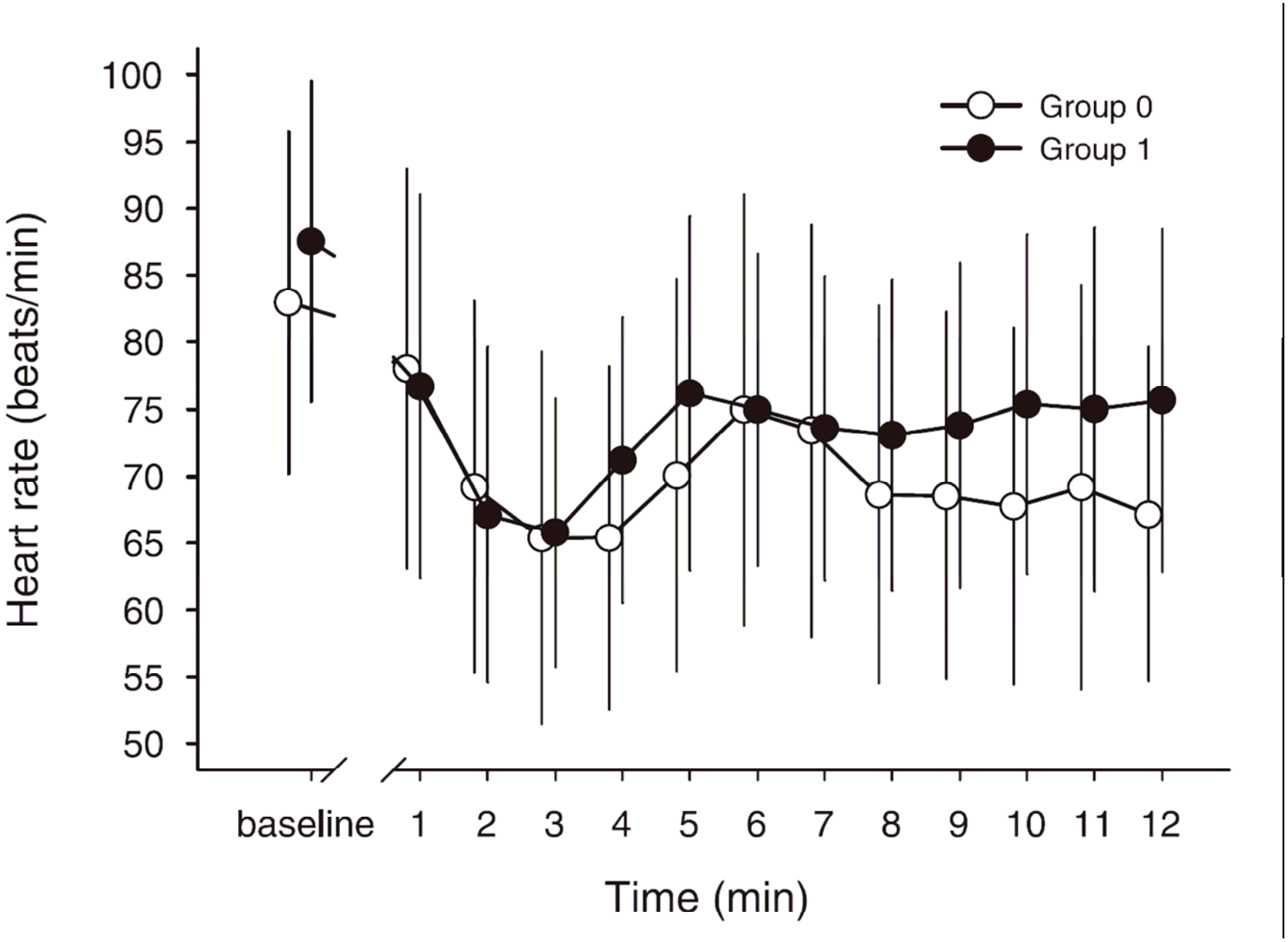
The Dose-Dependent Effects of Phenylephrine for Elective Cesarean Delivery Under Spinal Anesthesia

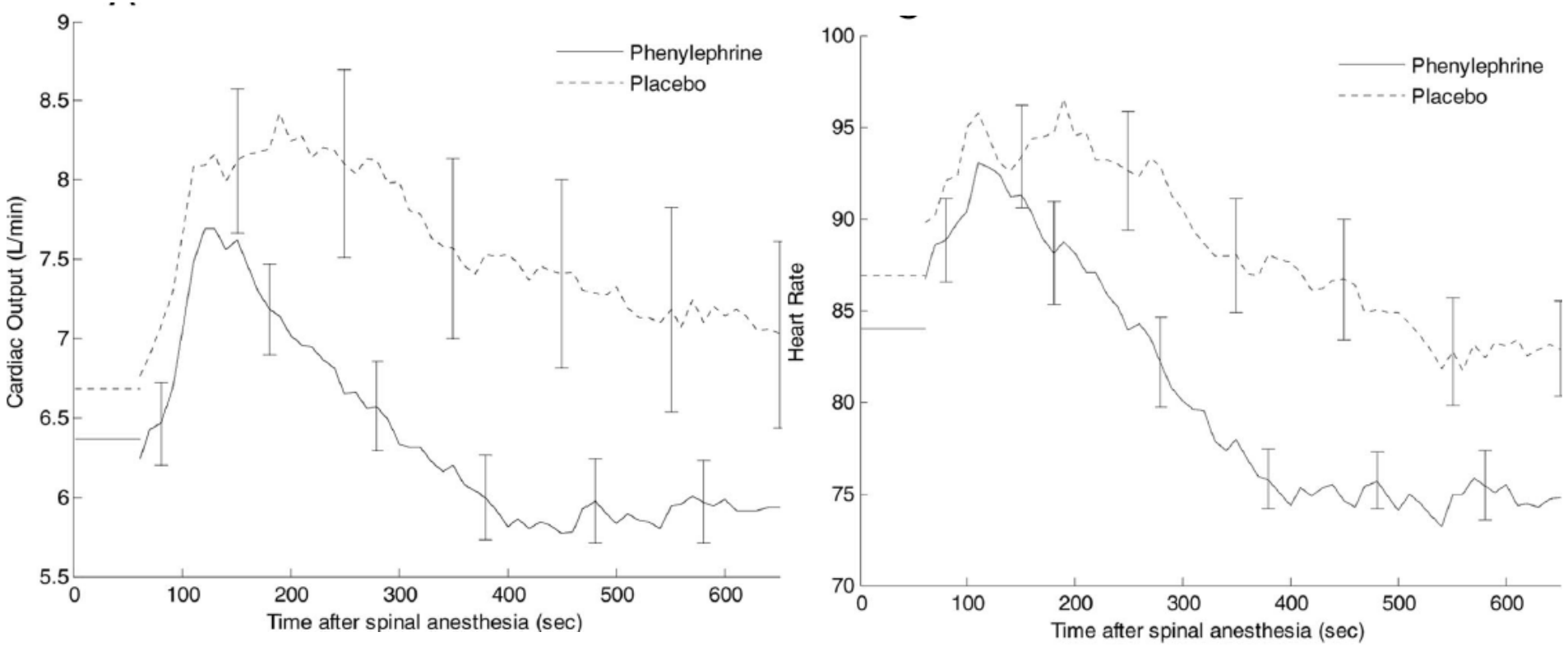
Stewart et al, Anesth Analg **2010**





Ngan Kee et al. Anesthesiology **2005**

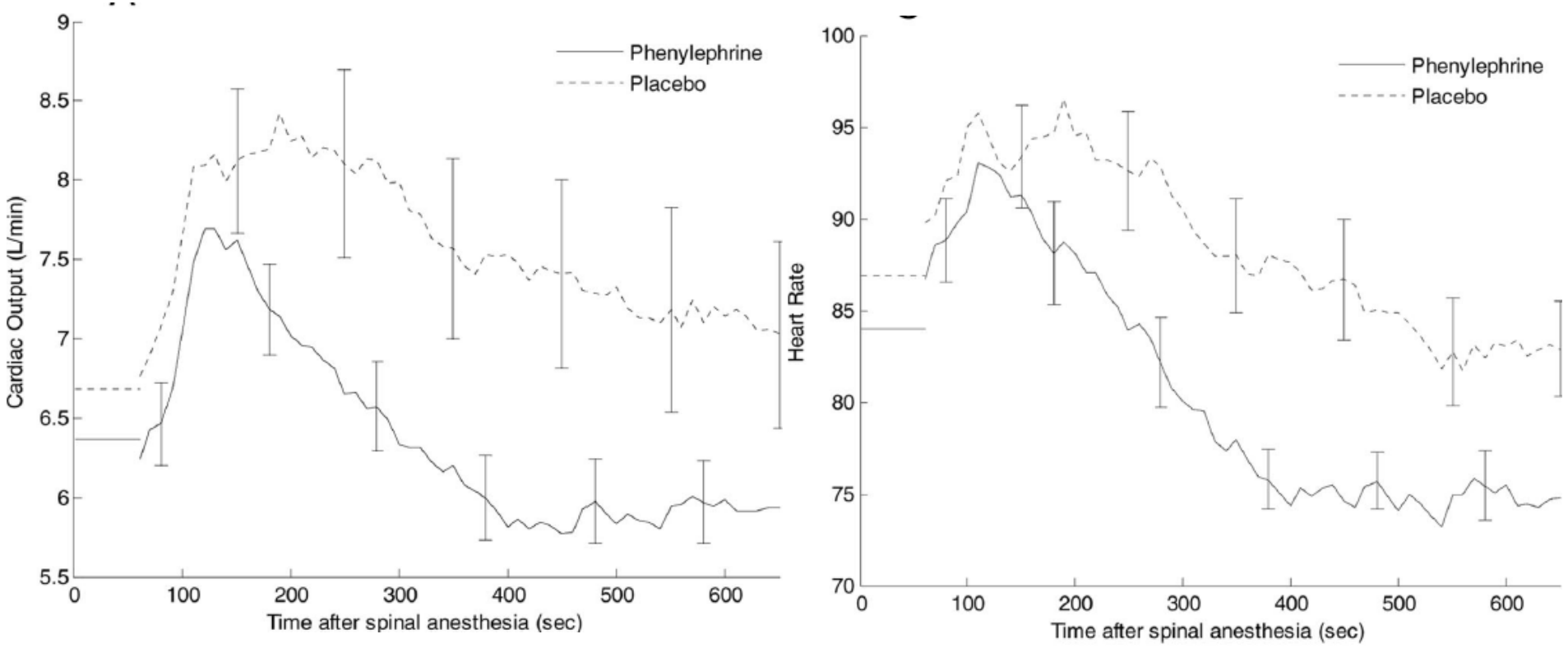




Langesæter et al. Anesthesiology **2008**

Phenylephrine has a negative effect on cardiac output

Heart rate is a good surrogate for cardiac output

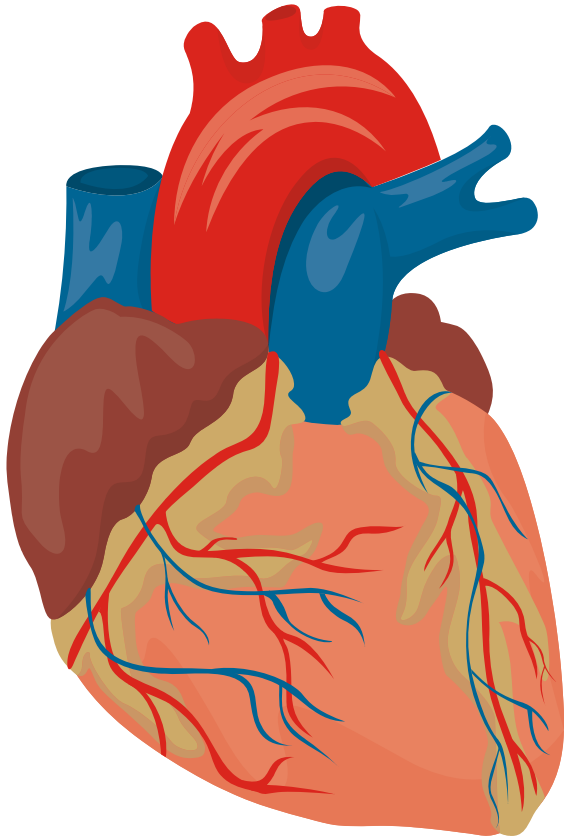


Langesæter et al. Anesthesiology **2008**

Focus on flow and pressure

CO = HR x SV

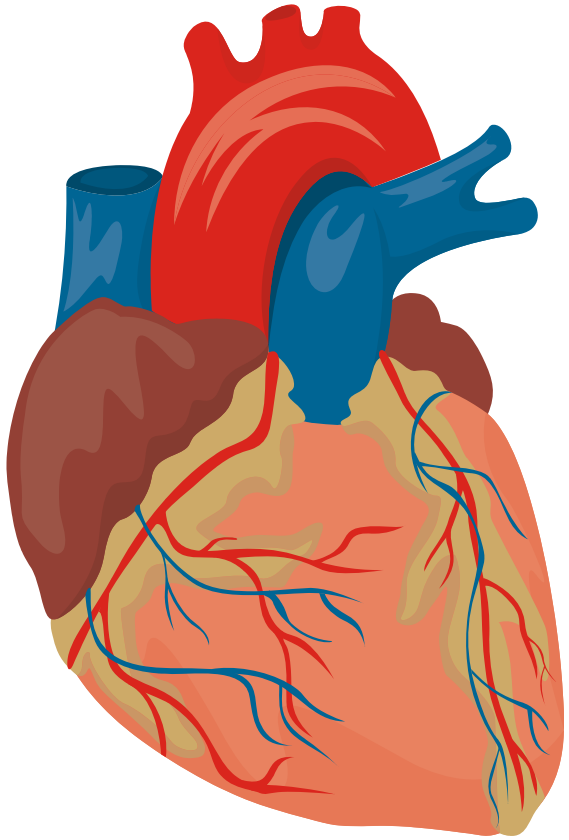
MAP = CO x SVR



Focus on flow and pressure

CO = HR x SV

MAP = CO x SVR



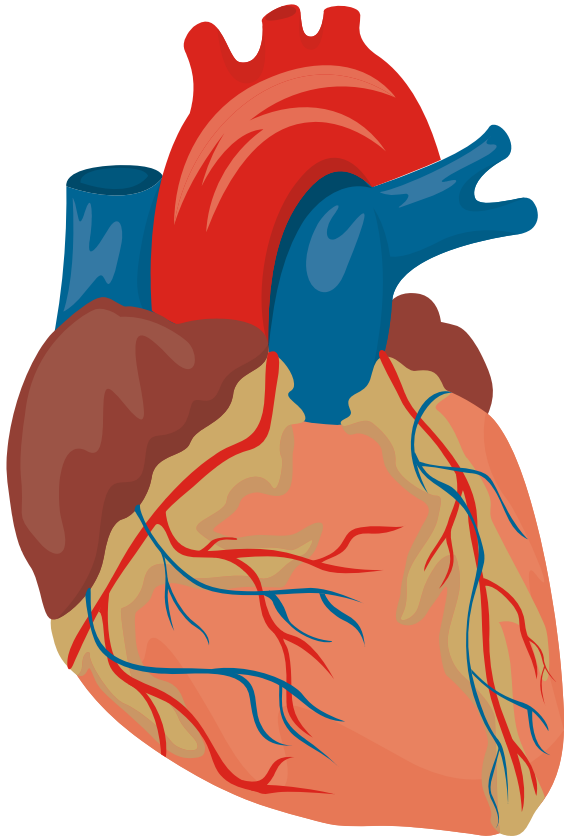
Hypotension and bradycardia

→ ephedrine (increasing HR)

Focus on flow and pressure

CO = HR x SV

MAP = CO x SVR



Hypotension and tachycardia

→ phenylephrine (increasing SVR)

The Physiologic Implications of Isolated Alpha$_1$ Adrenergic Stimulation

The Clinical Implications of Isolated Alpha$_1$ Adrenergic Stimulation

Thiele et al. Anesth Analg, August **2011**

What about the fetus?

- Both ephedrine and phenylephrine are safe
- Statistical significantly differences in UA pH, but no clinical implications

Placental Transfer and Fetal Metabolic Effects of Phenylephrine and Ephedrine during Spinal Anesthesia for Cesarean Delivery

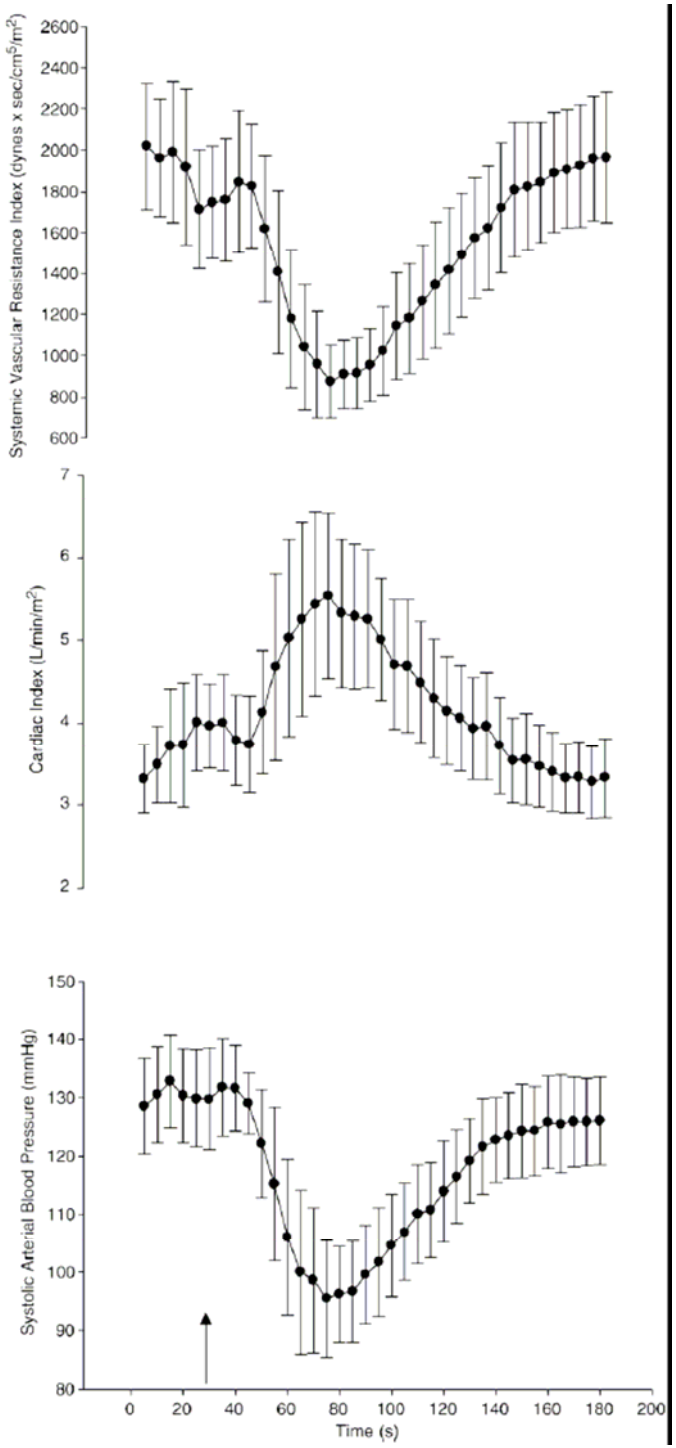
Ngan Kee et al. Anesthesiology **2009**

Mean doses
1300 µg Phenylephrine
62 mg Ephedrine

UA pH 7.25 vs 7.34

BE -4.8 vs -1.9mmol/L

Lactate 4.2 vs 2.2mmol/L



OXYTOCIN 5 IE i.v

Langesæter et al. Int J Gyn Obst **2006**

ED95% is 0.35 units (not in labor)
ED95% is 3 units (in labor)

Carvalho et al. Obst Gyn **2004**
Balki et al. Obst Gyn **2006**

Signs of myocardial ischaemia after injection of oxytocin: a randomized double-blind comparison of oxytocin and methylergometrine during Caesarean section

Svanstrøm et al,BJA **2008**

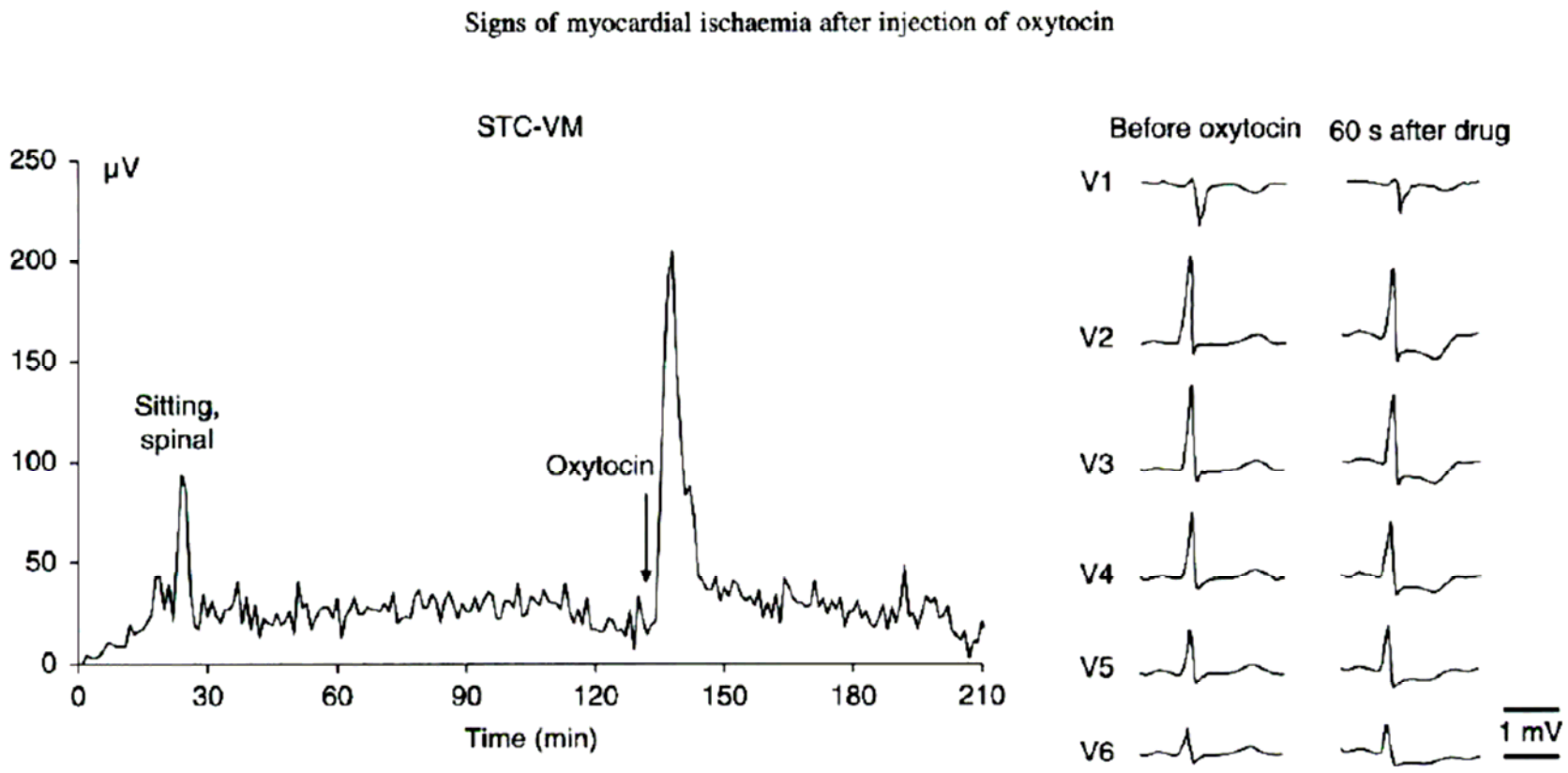
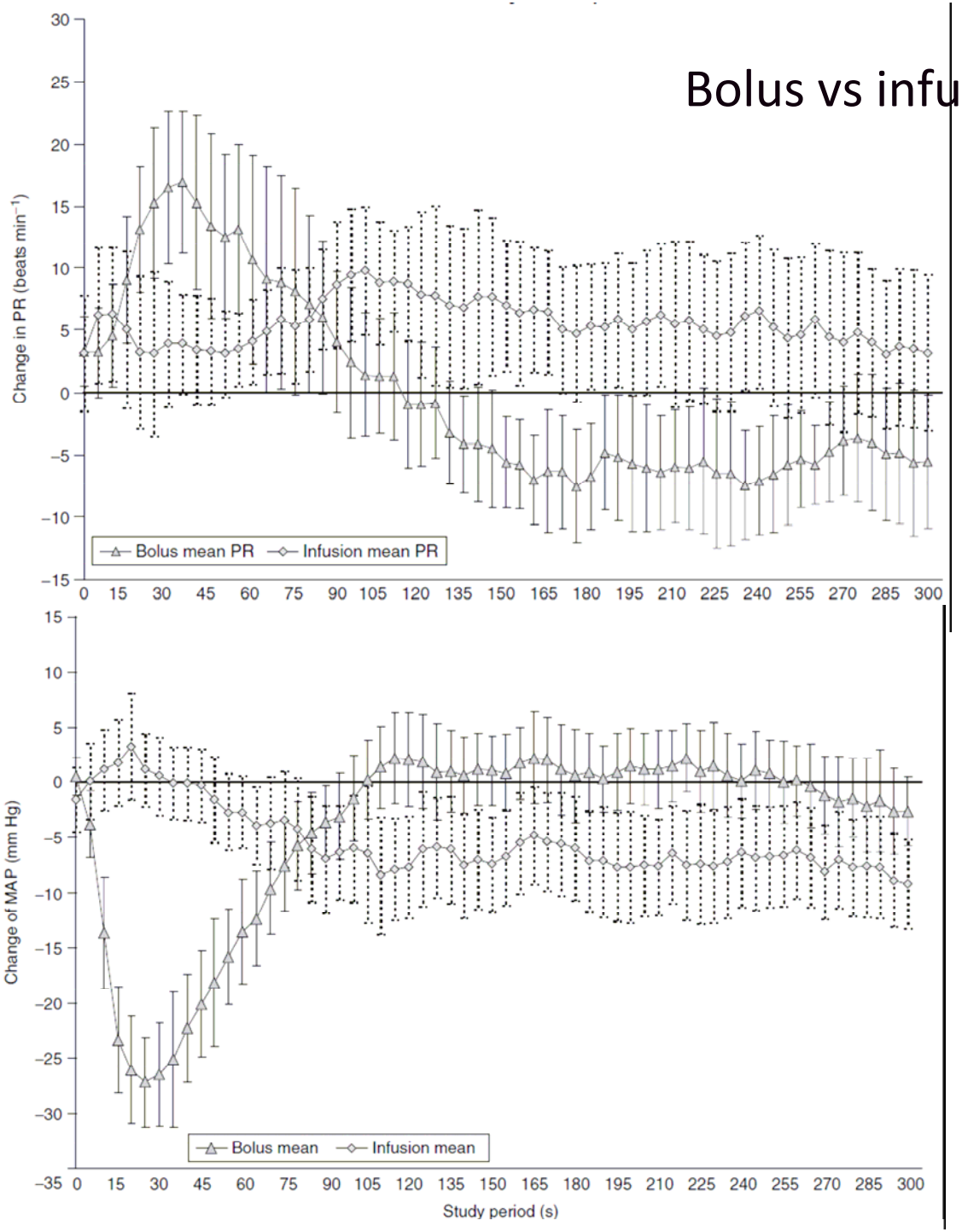


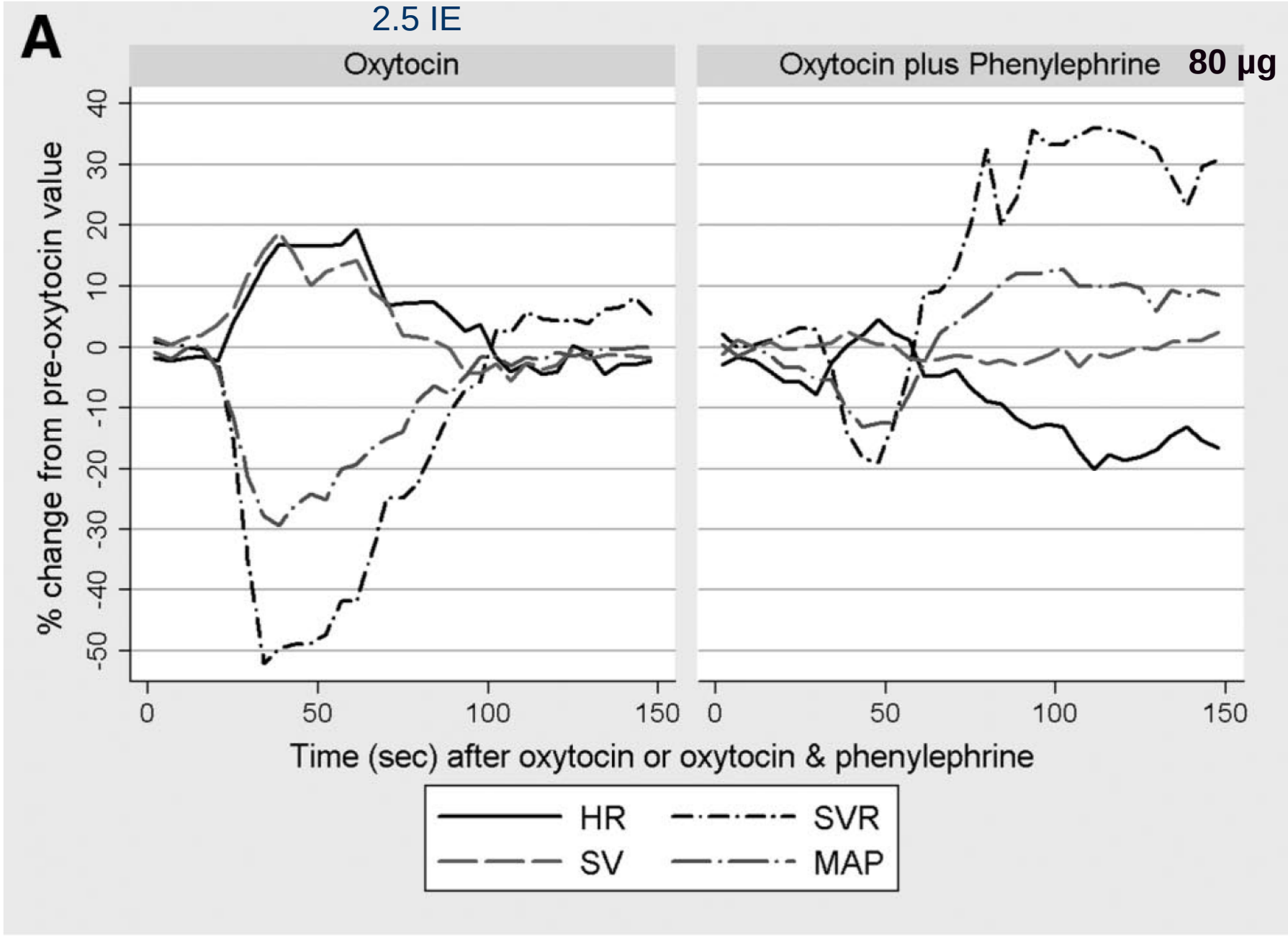
Fig 3 Recordings of scalar ECG and VCG in one OXY-CS woman after 10 IU of oxytocin i.v. Note the pronounced peak in STC-VM in the VCG trend curve and the ST-segment depression in the scalar ECG.

Bolus vs infusion, 5 IE Oxytocin



Thomas et al. BJA **2007**

Dyer et al. Anesthesiology **2009**



Why monitor cardiac output?

- Research
- Guide therapy

CO-monitoring in obstetric patients

- PA-catheter
- PiCCO
- Suprasternal Doppler
- Transthoracic bioimpedance
- Vigileo/Flotrac
- LiDCO*plus*

The LiDCO*plus* monitor

- A peripheral venous and arterial line
  - PulseCO
  - LiDCO

Anesthesiology 2008; 108

Pauca, A.

Pressure Wave Analysis Is Useful to Understand the Pathophysiology of Preeclampsia, but Perhaps Not the Rapid Changes during Cesarean Delivery

Comparison between pulse waveform analysis and thermodilution cardiac output determination in patients with severe pre-eclampsia

Dyer et al. BJA **2011**

Key points

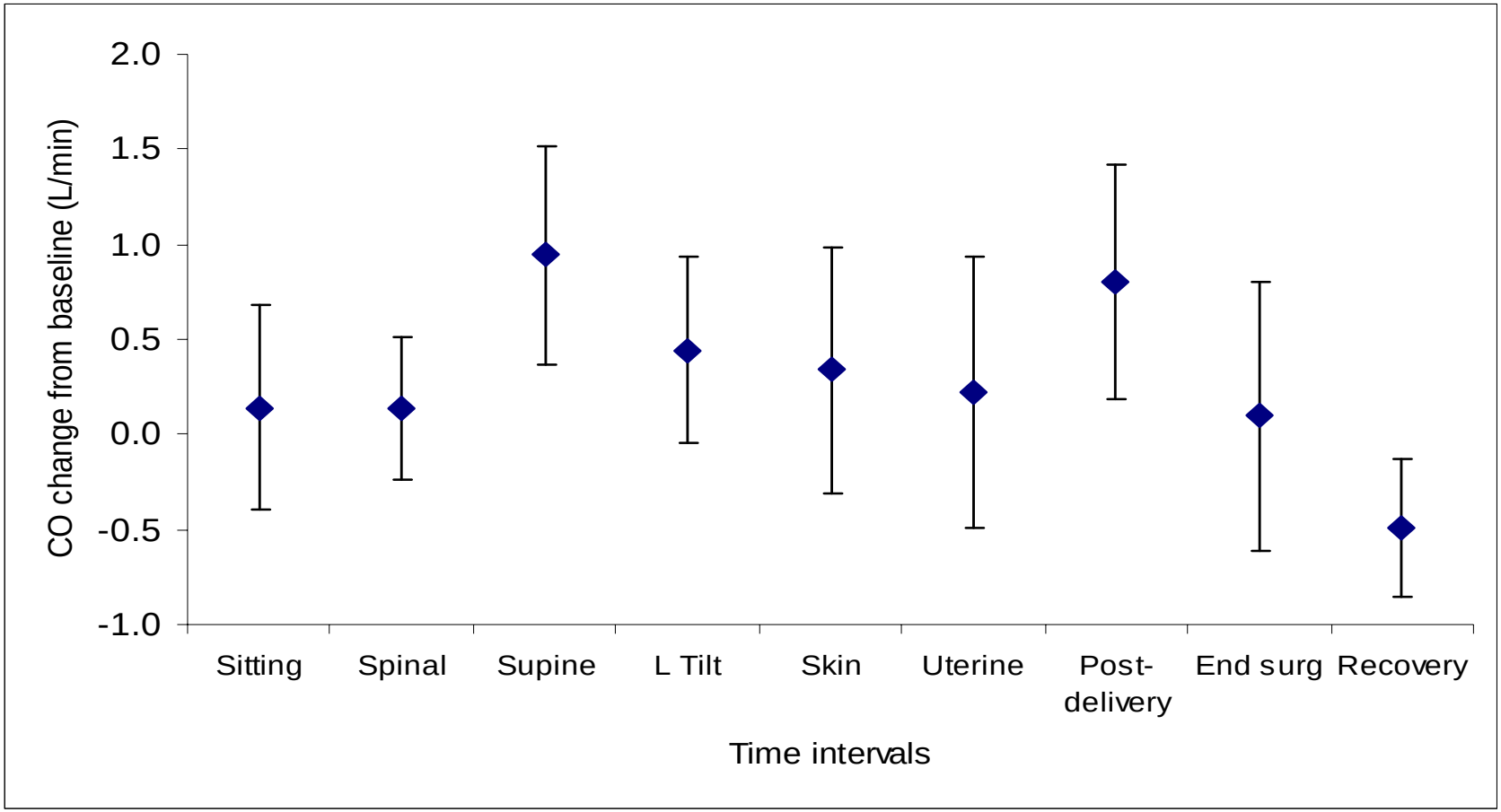
- Cardiac output (CO) monitoring may be of value in patients with complicated severe pre-eclampsia.
- In view of potential risks of pulmonary artery catheter (PAC) insertion, thermodilution CO measurements were compared with values obtained from the minimally invasive LiDCO*plus* monitor.
- The comparison showed a statistically but not clinically significant bias after central venous calibration with lithium, and no significant bias after peripheral venous calibration.
- These findings support the use of LiDCO*plus* for haemodynamic monitoring in patients with complicated severe pre-eclampsia.

These findings support the use of LiDCO*plus* for haemodynamic monitoring in patients with complicated severe pre-eclampsia.

Anesthesiology 2008; 108:802–11

Hemodynamic Changes Associated with Spinal Anesthesia for Cesarean Delivery in Severe Preeclampsia

Robert A. Dyer, F.C.A. (S.A.), Jenna L. Piercy, F.C.A. (S.A.),† Anthony R. Reed, F.R.C.A.,† Carl J. Lombard, Ph.D.,‡ Leann K. Schoeman, F.C.O.G. (S.A.),§ Michael F. James, Ph.D.‖*



Editorial I

Hypotension in obstetric spinal anaesthesia: a lesson from pre-eclampsia

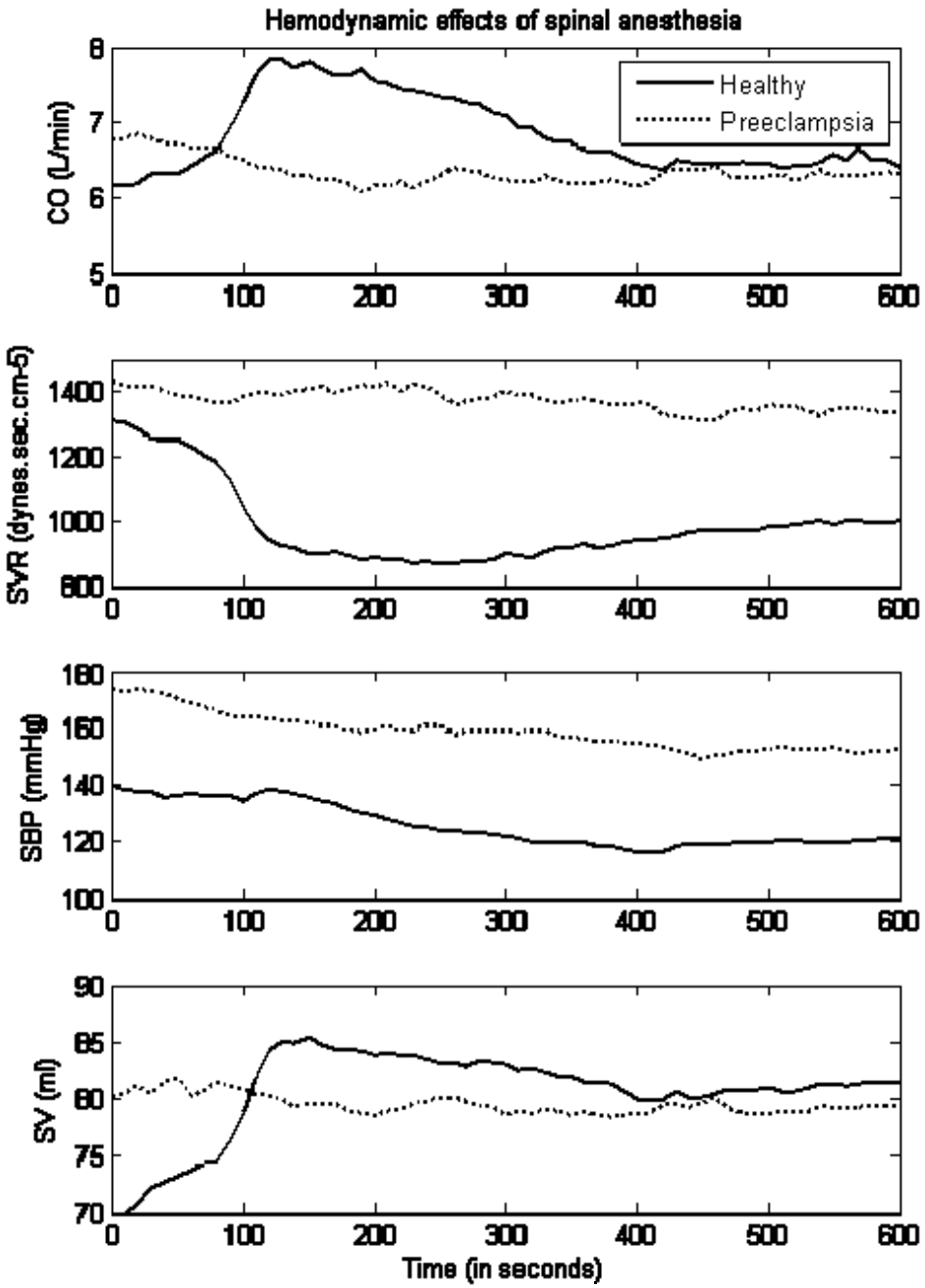
Sharwood-Smith & Drummond, BJA **2009,**

STUDIES ON AUTONOMIC BLOCKADE. I. COMPARISON BETWEEN THE EFFECTS OF TETRAETHYLAMMONIUM CHLORIDE (TEAC) AND HIGH SELECTIVE SPINAL ANESTHESIA ON BLOOD PRESSURE OF NORMAL AND TOXEMIC PREGNANCY [1]

By N. S. ASSALI and HARRY PRYSTOWSKY [2]

Submitted for publication March 23, 1950

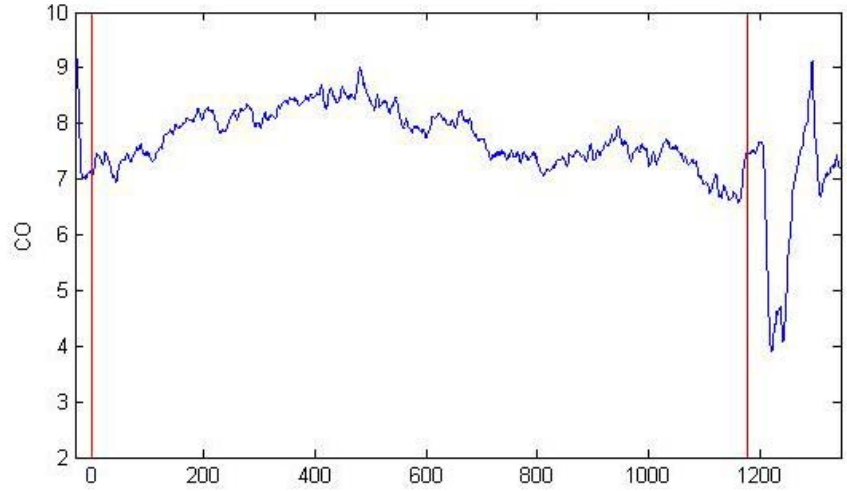
Haemodynamic effects of spinal anaesthesia in healthy vs severe preeclamptic



32 patients with severe PE

80 healthy pregnant

(unpublished)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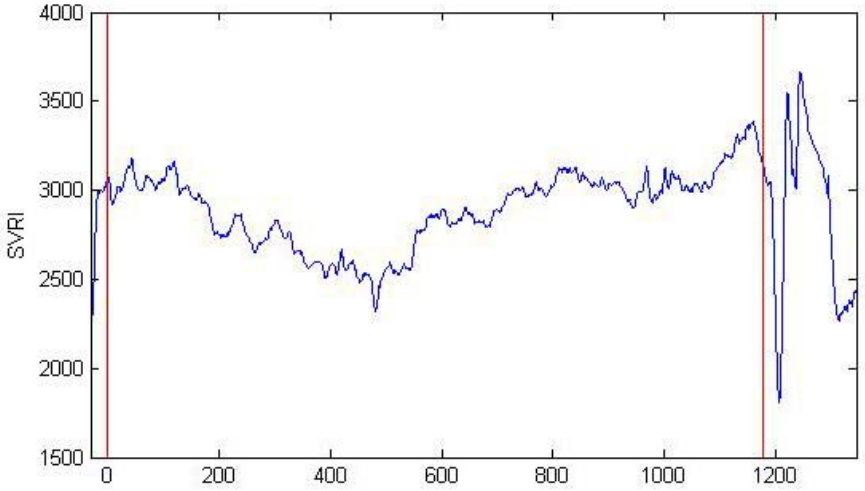
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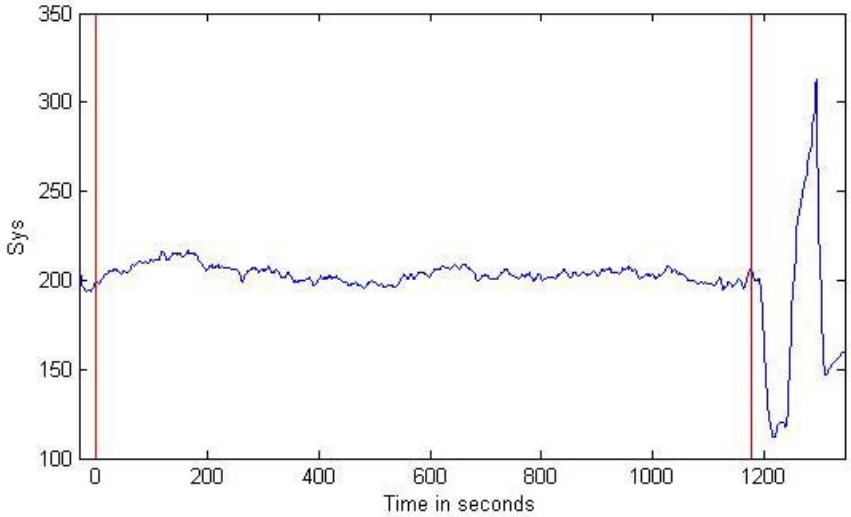
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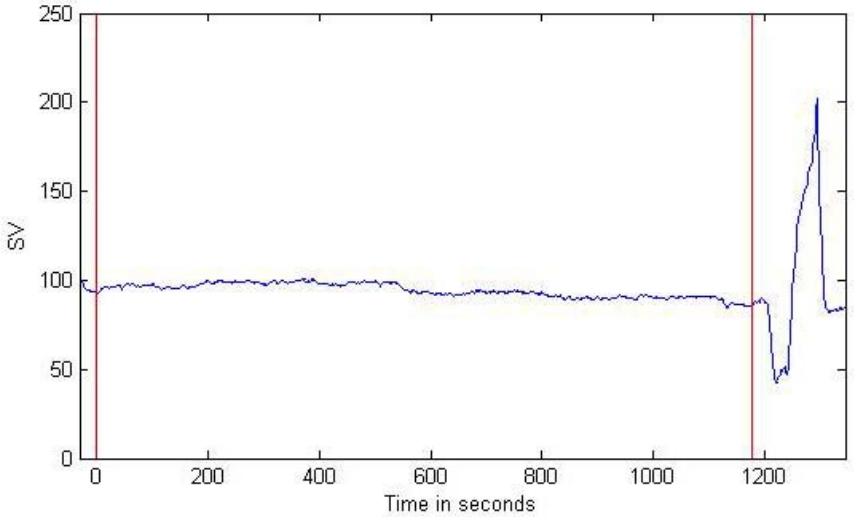
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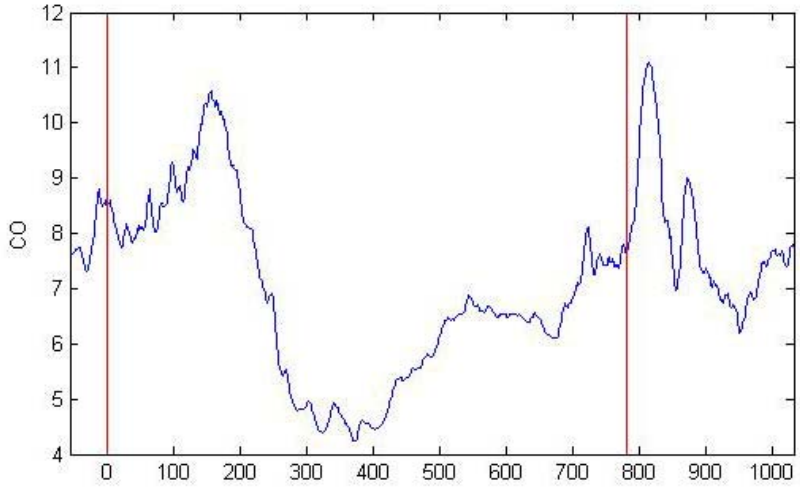
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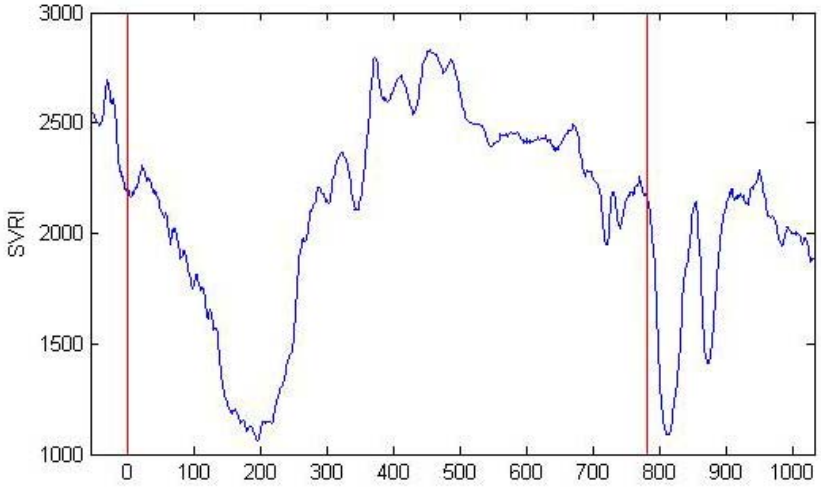
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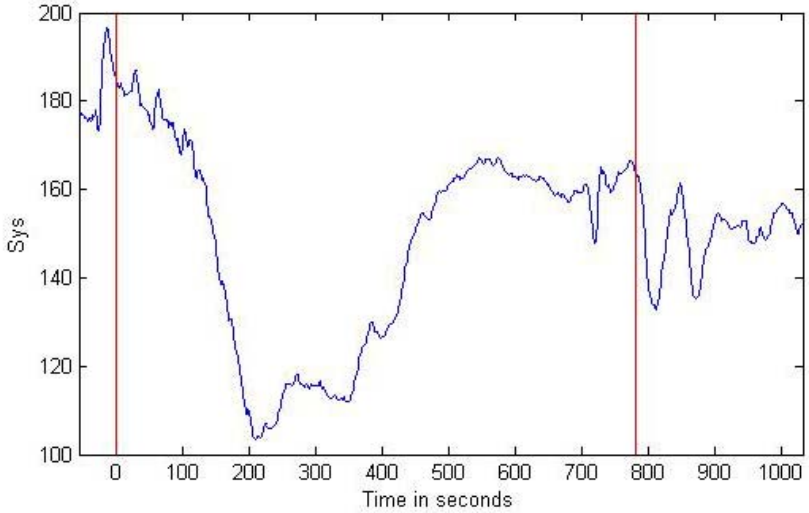
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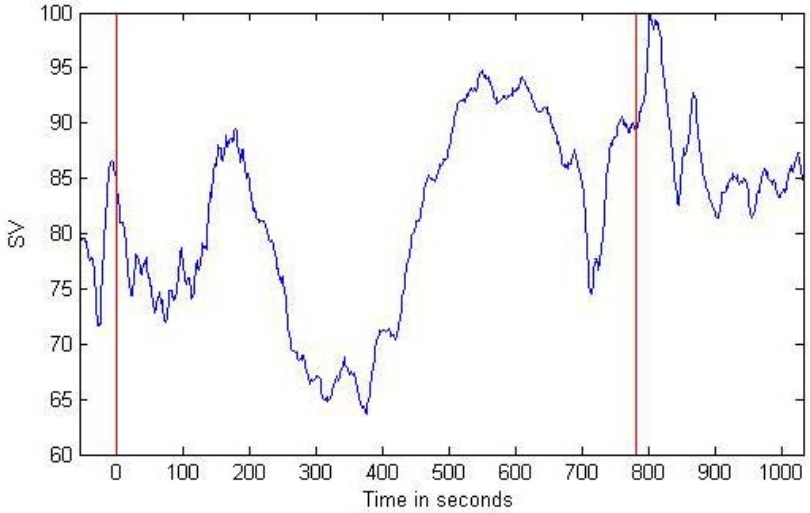
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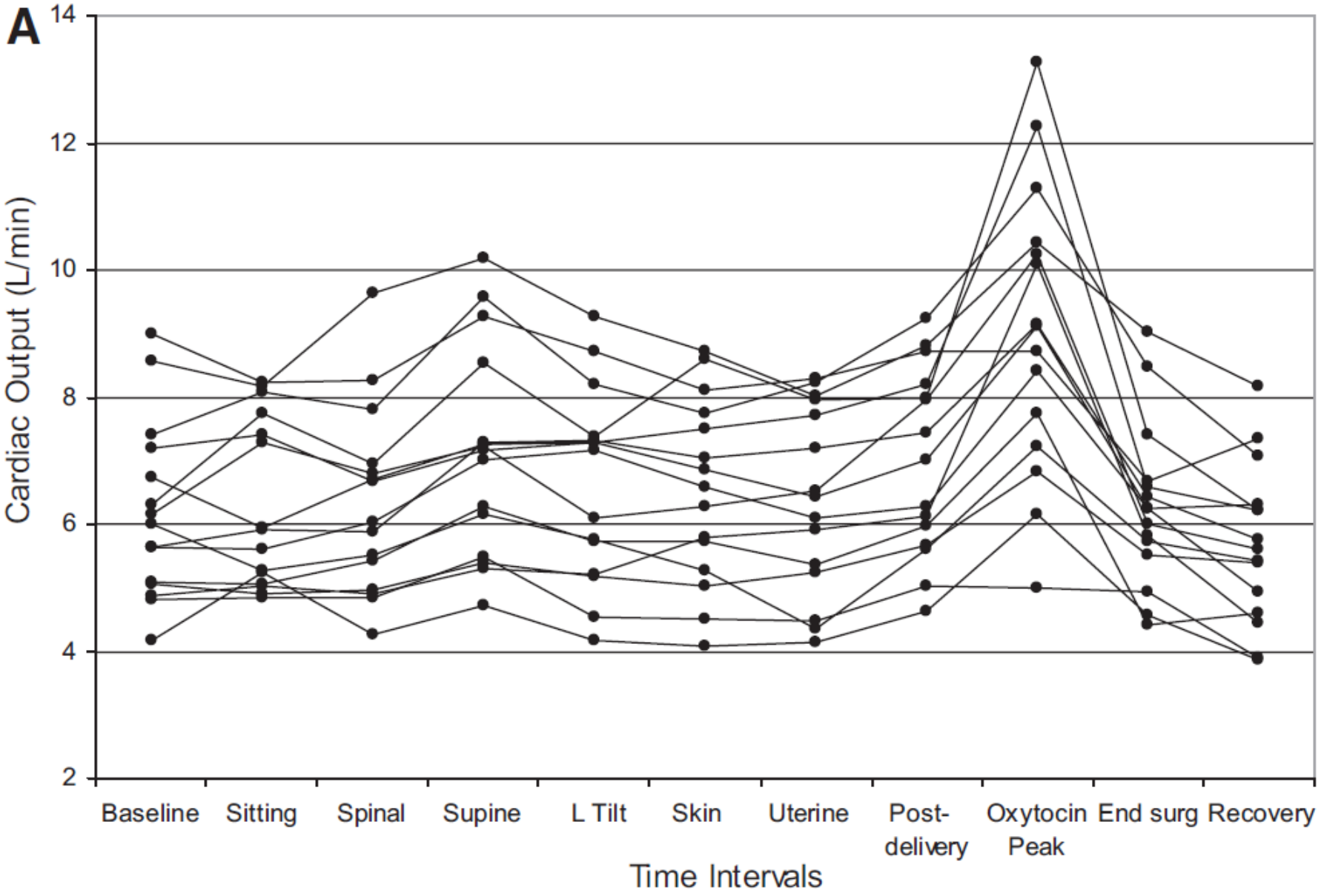
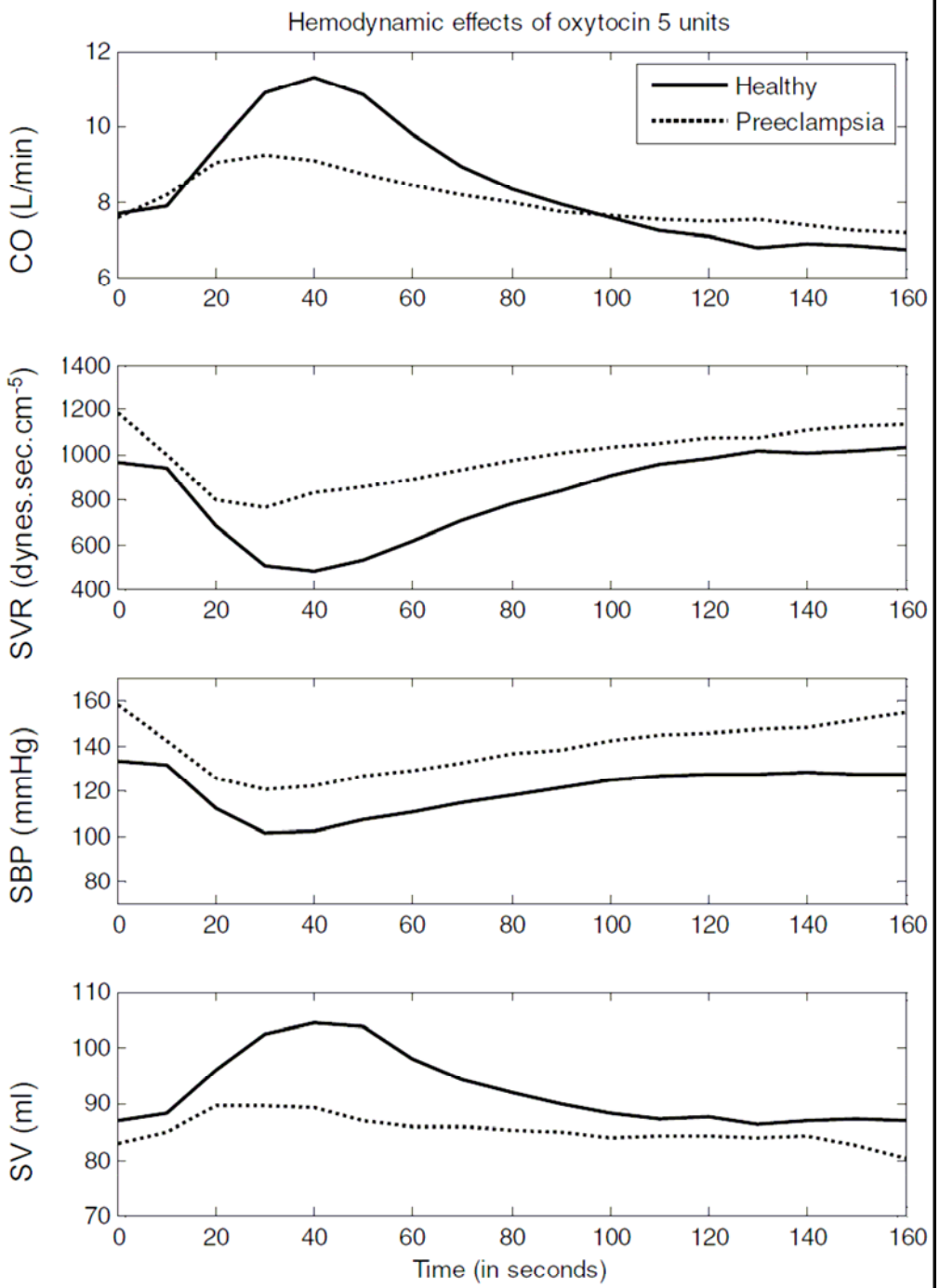


Dyer et al. Anestesiology **2008**

Haemodynamic effects of oxytocin in women with severe preeclampsia

Langesæter et al. IJOA **2011**

5/18 women with severe preeclampsia had a decrease in cardiac output after 5 units oxytocin iv



5 units oxytocin iv

18 women with
severe preeclampsia

80 healthy pregnant women

Substandard care

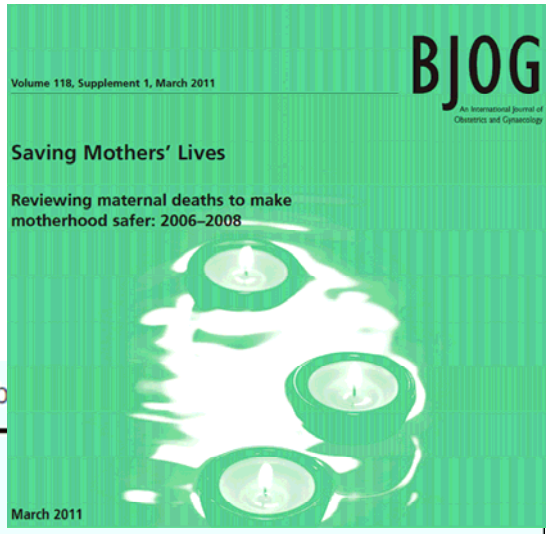


Table 1.12. Numbers and percentages of cases of *Direct* and *Indirect* deaths by cause and degree of sub

Cause	Numbers of cases			Percentages of cases				
	Major	Minor	Total	Major	Minor	Total	no SSC	
Direct								
Thrombosis and thromboembolism	6	4	10	33	22	56	44	18
Pre-eclampsia, eclampsia and acute fatty liver of pregnancy	14	6	20	64	27	91	9	22
Haemorrhage	4	2	6	44	22	67	33	9
Amniotic fluid embolism	2	6	8	15	46	62	38	13
Early pregnancy deaths	6	–	6	55	–	55	45	11
Sepsis	12	6	18	46	23	69	31	26
Anaesthesia	3	3	6	43	43	86	14	7
Total *Direct*	47	28*	75*	44	26	70	30	107*
Indirect								
Cardiac disease	13	14	27	25	26	51	49	53
Other *Indirect* causes	17	11	28	33	21	54	46	52
Indirect neurological causes	11	12	23	31	33	64	36	36
Psychiatric causes	6	1	7	46	8	54	46	13
Total *Indirect*	47	38	85	31	25	55	45	154
Total *Direct* and *Indirect*	94	66	160	36	25	61	39	261

Guidelines

- BPs < 160 mmHg
- MgSO4
- Fluid restriction

CONTROVERSIES

1999

Fluid restriction policies in preeclampsia are obsolete

Proposer: S.C. Robson
Department of Obstetrics & Gynaecology, University of Newcastle upon Tyne, Newcastle, UK

Opposer: J. F. Pearson
University of Wales College of Medicine, Cardiff, UK

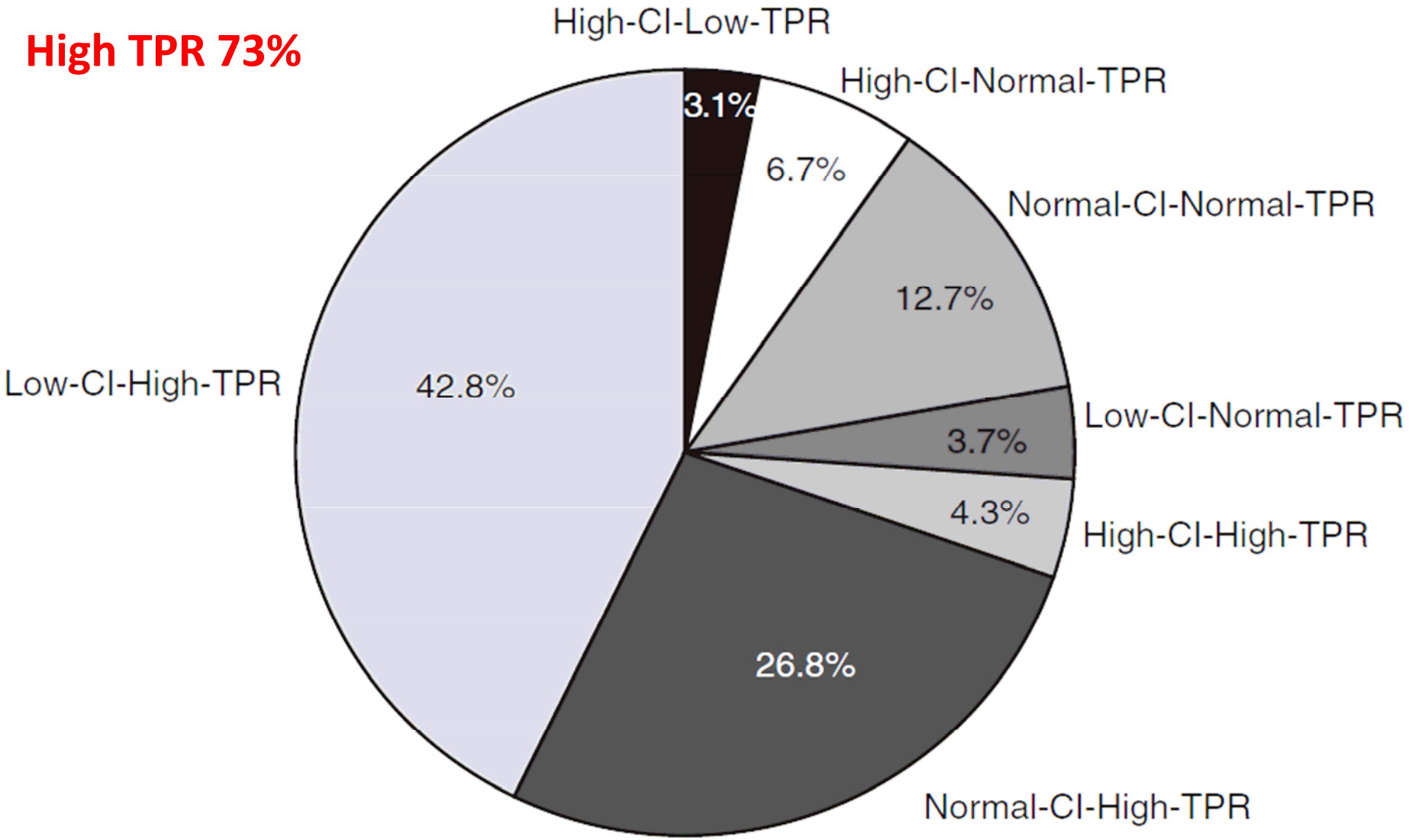
A randomised controlled trial comparing two temporising management strategies, one with and one without plasma volume expansion, for severe and early onset pre-eclampsia

Ganzevoort el al. BJOG **2005**

Pre-eclampsia outcomes in different hemodynamic models

Mei et al. J Obst Gyn Res **2008**.34(2):179-88

High TPR 73%



Pre-delivery

Case A	Case B
BP 193/90 (135)	**BP 190/96 (130)**
CO 5.3 l/min	CO 9.3 l/min
SVR 1900	SVR 1100

Postpartum

Case A

BP 145/86 (110)

SV 49

CO 2.9 l/min

SVR 2800

Case B

BP 147/79 (105)

SV 141

CO 9.0 l/min

SVR 900

Postpartum

Case A

BP 145/86 (110)

SV 49

CO 2.9 l/min

SVR 2800

- Vasodilatation and plasma volume-expansion
  - 10 litre crystalloids (24 hours)

Case B

BP 147/79 (105)

SV 141

CO 9.0 l/min

SVR 900

- Diuretics

The role of the anaesthetist in the management of the pre-eclamptic patient

Robert A. Dyer, Jenna L. Piercy and Anthony R. Reed

Current Opinion in Anaesthesiology 2007, 20:168–174

”.., calibrated pulse contour or pulse power algorithms may have a valuable future role, because only an arterial and peripheral line are required. Simply measuring cardiac output and blood pressure allows calculation of the systemic vascular resistance, which guides the appropriate use of fluids, diuretics, vasodilators and, occasionally, inotropes.”

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Treatment must be individualized

Cardiac disease

- A multidisciplinary team
- Risk classification
  - Diagnosis
  - Functional capacity
  - Obstetrical history

MAKE A PLAN

- A planned delivery (CS) at day time in high risk patients

Regional anaesthesia in pregnant women with cardiac disease

1. 34 patients, NYHA II-III
   - Arterial line
   - CSA

   Dresner et al. IJOA **2009**

2. 103 deliveries
   - CO-monitoring
   - Spinal, CSE, CSA

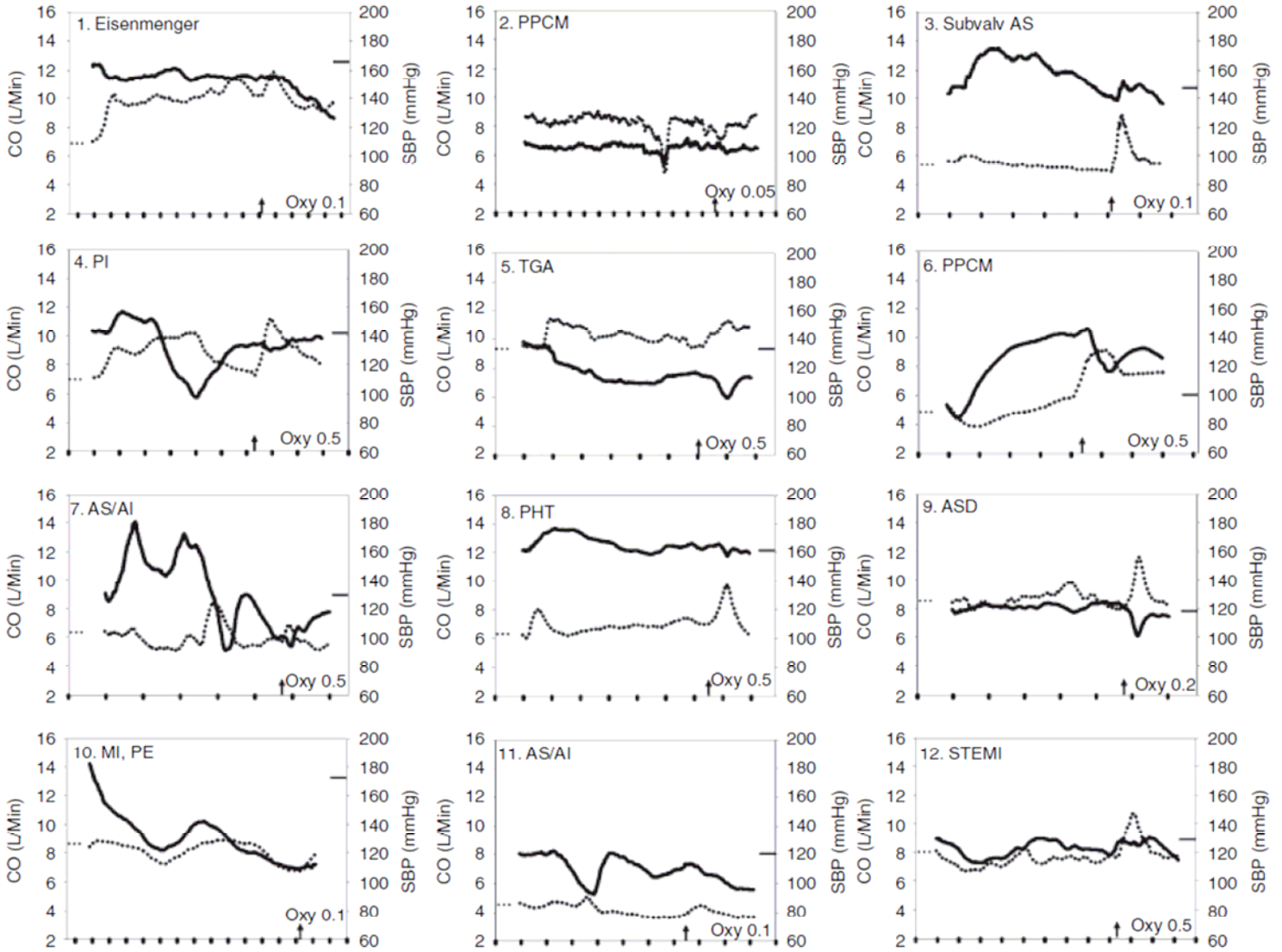
   Langesæter et al. Acta Anaesth Scand **2010**

3. 9 patiens with PHT

   Kiely et al. BJOG **2010**

Regional anaesthesia for a Caesarean section in women with cardiac disease: a prospective study

Langesæter et al. Acta Anesth Scand **2010**

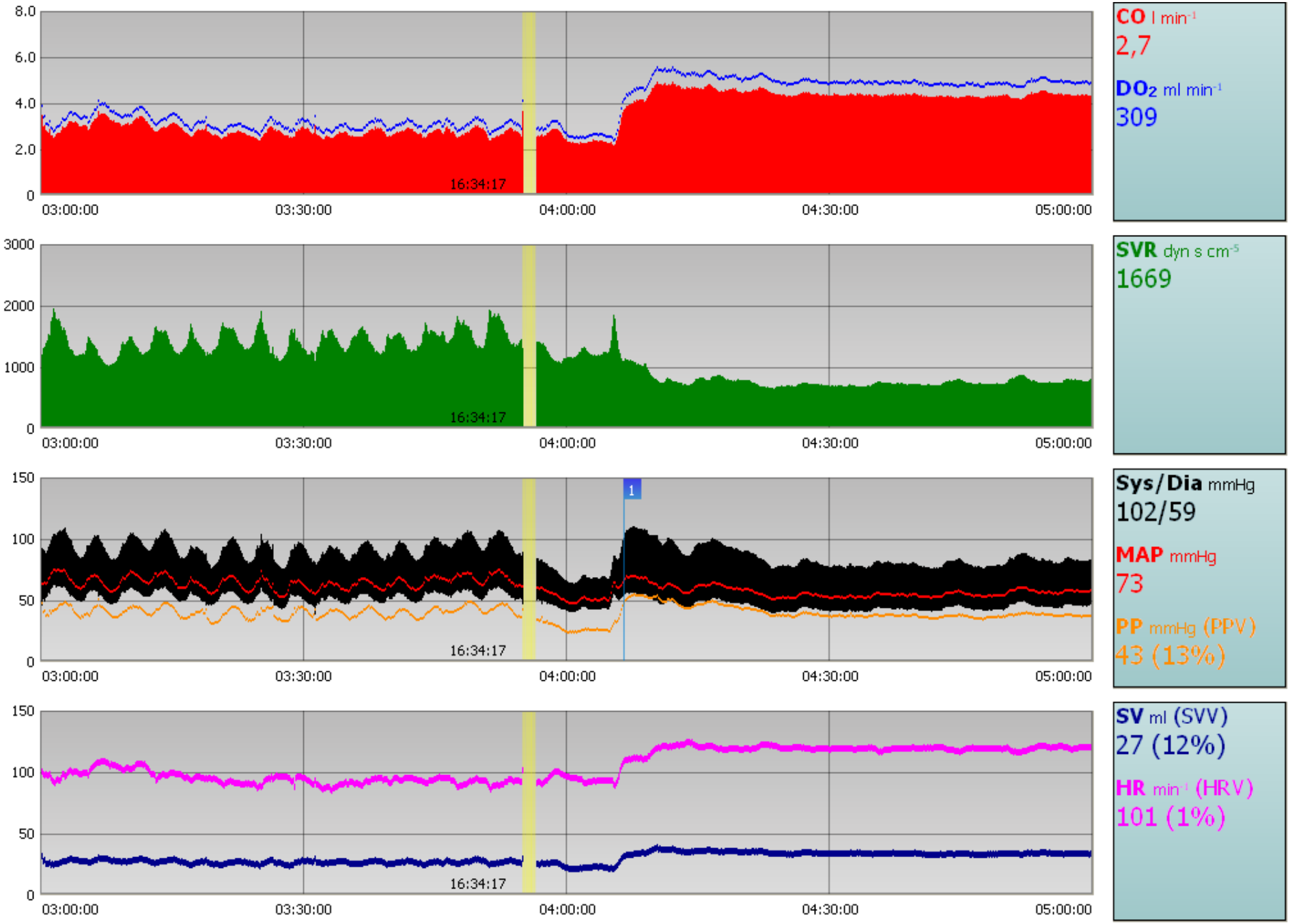


Amniotic fluid embolism

- Cardiac arrest during vaginal delivery
- Resuscitated 45 min
- DIC, massive transfusion
- Transport to Rikshospitalet after 12 hours
  - Still bleeding, DIC
  - FiO2 1.0, NO-gas
  - Noradrenaline 0.15µg/kg/min
  - Dopamine 10µg/kg/min
  - Lactate 16

- Ecco cor
  - CO 2.7 l/min
- Vasodilatation
- Inotropy
- Volume

Amniotic fluid embolism



Key points - HEALTHY

- The main effects of spinal anaesthesia is
  - A rapid and prominent decrease in SVR
  - A compensatory increase in CO

- Phenylephrine is the vasopressor of choice because it restores maternal haemodynamics, not because of the statistically significantly higher UA pH

- Heart rate is a good surrogate for cardiac output

Maternal haemodynamic changes during spinal anaesthesia for caesarean section

Eldrid Langesæter[a] and Robert A. Dyer[b]

Current Opinion in Anesthesiology 2011, 24:242–248

Key points

- The typical haemodynamic effects of spinal anaesthesia in healthy pregnant women are a decrease in systemic vascular resistance and a compensatory increase in cardiac output; phenylephrine is, thus, the first-line vasopressor.
- The rarer presentation of hypotension and bradycardia should be treated with ephedrine and/or anticholinergics.
- The same principles can be applied in pregnant women with cardiac disease, who warrant close haemodynamic monitoring and careful titration of doses of local anaesthetic and vasopressors, using a sequential combined spinal-epidural or continuous spinal technique.
- Patients with early-onset and late-onset preeclampsia may have differing haemodynamic characteristics, with implications for anaesthetic management.

Oxytocin for labour and caesarean delivery: implications for the anaesthesiologist

Robert A. Dyer[a], Alexander J. Butwick[b] and Brendan Carvalho[b]

Current Opinion in Anesthesiology 2011, 24:255–261

Key points

- Oxytocin remains the first-line agent for the prevention and treatment of uterine atony and postpartum haemorrhage.
- Prolonged exposure to oxytocin induces oxytocin receptor desensitization, which may result in greater oxytocin requirements and/or the use of second-line uterotonics at delivery.
- Oxytocin has a narrow therapeutic range and causes a number of dose-related side-effects in particular hypotension and tachycardia.
- Slow administration of a small (1–3 IU) bolus of oxytocin during caesarean section suffices for the prevention of uterine atony in most cases, and reduces adverse effects.