

# Use of a Minimally Invasive Uncalibrated Cardiac Output Monitor in Patients Undergoing Cesarean Section under Spinal Anesthesia: Report of Four Cases

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**Summary:** Bliacheriene F, Carmona MJC, Barretti CFM, Haddad CMF, Mouchalwat ES, Bortolotto MRFL, Francisco RPV, Zugaib M – Use of a Minimally Invasive Uncalibrated Cardiac Output Monitor in Patients Undergoing Cesarean Section under Spinal Anesthesia: Report of Four Cases.

**Background and Objectives:** Hemodynamic changes are observed during cesarean section under spinal anesthesia. Non-invasive blood pressure (BP) and heart rate (HR) measurements are performed to diagnose these changes, but they are delayed and inaccurate. Other monitors such as filling pressure and cardiac output (CO) catheters with external calibration are very invasive or inaccurate. The objective of the present study was to report the cardiac output measurements obtained with a minimally invasive uncalibrated monitor (LiDCO rapid) in patients undergoing cesarean section under spinal anesthesia.

**Case report:** After approval by the Ethics Commission, four patients agreed to participate in this study. They underwent cesarean section under spinal anesthesia while at the same time being connected to the LiDCO rapid by a radial artery line. Cardiac output, HR, and BP were recorded at baseline, after spinal anesthesia, after fetal and placental extraction, and after the infusion of oxytocin and metaraminol. We observed a fall in BP with an increase of HR and CO after spinal anesthesia and oxytocin infusion; and an increase in BP with a fall in HR and CO after bolus of the vasopressor.

**Conclusions:** Although this monitor had not been calibrated, it showed a tendency for consistent hemodynamic data in obstetric patients and it may be used as a therapeutic guide or experimental tool.

**Keywords:** Anesthesia, Spinal; Monitoring, Intraoperative; Hemodynamics; Cardiac Output; Hypotension; Cesarean Section.

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## INTRODUCTION

Spinal anesthesia has been consolidating as the technique of choice for cesarean section worldwide<sup>1</sup> due to the quality of the blockade and safety of the technique, using small anesthetic mass and not requiring ventilatory assistance and tracheal intubation.

However, it produces a non-selective blockade: the synapses in sensorial, motor, and autonomic fibers are temporarily interrupted. The autonomous blockade is regional, but intense enough to lead to severe hemodynamic changes, such as hypotension. The sympathetic blockade is not the only cause of hypotension; aortocaval compression by the fetus<sup>2</sup> and infusion of oxytocin<sup>3</sup> also contribute.

The diagnosis of hemodynamic compromise during cesarean section under spinal anesthesia is usually non-invasive, such as heart rate and non-invasive blood pressure monitors, used as substitute markers of maternal cardiac output<sup>4</sup>. However, the delay and the lack of accuracy of these parameters in reflecting the fall in uterine-placental blood flow are significant<sup>5</sup>. Cardiac filling pressure catheters, besides being very invasive, also may be unreliable. Cardiac output (CO) is considered one of the most accurate parameters to detect these changes<sup>6</sup> and has better correlation with uterine-placental blood flow<sup>7</sup>. With the advent of minimally invasive equipment to measure CO, the opportunity to investigate this parameter in the obstetric population has emerged. However, most of these equipments require external calibration resulting in a more cumbersome operation and greater invasiveness. Therefore, the objective of the present study was to observe the

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behavior of CO measured by a minimally invasive uncalibrated monitor (LiDCO rapid) in patients undergoing cesarean section under spinal anesthesia.

## METHODS

After approval by the Ethics Committee of the institution, patients referred to the pre-delivery unit of the Obstetric Center were questioned whether they wanted to participate in the study. Detailed information on the protocol and procedures emphasizing the voluntariness of participation without any repercussions on treatment in case they did not wish to participate was provided. Four patients agreed to participate and they signed an informed consent. Exclusion criteria, besides refusal to give consent, were not established.

The patient was transferred to the operating room where venous cannulation was performed with an 18G catheter. This was followed by puncture of the radial artery with a 22G venous catheter for invasive blood pressure monitoring, which was connected to a minimally invasive uncalibrated cardiac output (CO) monitor (LiDCO rapid – Pulse CO system, LiDCO Ltda, Cambridge, GB). This equipment uses the algorithm of pulse power analysis with correction for anthropometric characteristics for individual arterial complacency, and external calibration was not performed. Thus, it converts changes in blood pressure over time on an estimate of the systolic volume and CO (nominal value), which can be used in the analysis of tendencies<sup>8</sup>.

The first measures of CO, BP, and heart rate (HR) were recorded with the patient in partial left lateral decubitus over a 15 degree wedge under the right gluteal region, considered the baseline measurements. The patient was, then, anesthetized with the standardized spinal anesthesia for cesarean section of the institution consisting of 15 mg of 0.5% hyperbaric bupivacaine associated with 80 µg of 0.02% morphine through a 27G Whitacre needle. The patient was once more placed on a 15 degree wedge on the right gluteal region resulting in uterine dislocation to the left<sup>9</sup> until after the surgical fields were placed, at which time the wedge was removed. Crystalloids were not administered before the spinal anesthesia<sup>10</sup>, but immediately after it, resulting in co-hydration with 10 mL.kg<sup>-1</sup> of Ringer's lactate<sup>11</sup>. Blood pressure was constantly monitored and any fall was immediately corrected to guarantee fetal well-being<sup>12</sup> with a bolus of 200 µg of metaraminol IV<sup>13</sup>, a predominantly alpha-agonist vasopressor<sup>14,15</sup>, and the measurements were recorded at this moment as "araminol". When incision of the skin was performed, hemodynamic parameters were recorded as "anesthesia", and we expected to be recording the peak of the sympathetic blockade. As soon as the fetus was extracted, followed by delivery of the afterbirth, new measurements were recorded as "birth". According to the protocol of the institution, 3 IU IV<sup>16</sup> of oxytocin over at least 60 seconds were infused, followed by recording of the measurements as "oxytocin". The infusion was repeated according to the evaluation of the uterine tonus by the obstetrician, up to a limit of 9 IU<sup>17</sup>. No patient required more oxytocin

or other classes of uterotonics, such as ergot derivatives or prostaglandins. The "final" measurement was recorded when closing of the aponeurosis. The arterial catheter was removed and pressure was applied to the puncture site for five minutes, and the patient was followed-up for eight hours for detection of any vascular complications. Data was stored and tabulated on the memory card of the LiDCO rapid monitor and treated by its specific software, the LiDCO view.

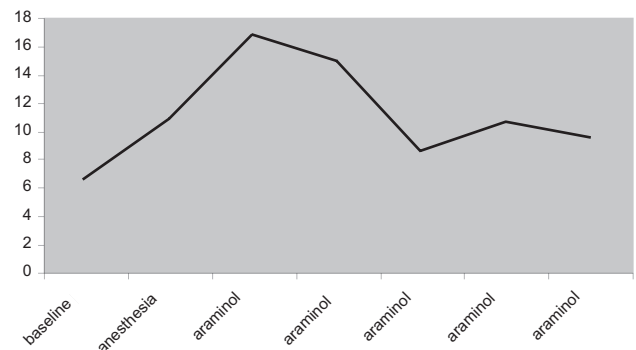
## CASE 1

This is a 39-year old, 86 kg, 165 cm, gesta 6 (2 cesarean sections and 3 abortions) with a diagnosis of a 34-week twin pregnancy, and acute fetal distress, which were the indications for cesarean section. Her physical status was classified as ASA II, since she had gestational diabetes on insulin, and hypertension controlled with alpha-methyldopa (1.5 g.day<sup>-1</sup>). The case developed according to that described in "methods", and the measurements are shown in Table I.

**Table I** – Case 1 Measurements

	CO	MAP	HR
Baseline	7.8	128	65
Anesthesia	7.6	122	64
Araminol	5.9	126	59
Birth	10.0	120	71
Oxytocin	11.2	92	94
Araminol	9.6	109	83
Final	7.4	125	56

CO: Cardiac Output in L.min<sup>-1</sup>; MAP: Mean Arterial Pressure in mmHg; HR: Heart Rate in beats.min<sup>-1</sup>.



**Figure 1** – CO in L.min<sup>-1</sup> in Case 1.

## CASE 2

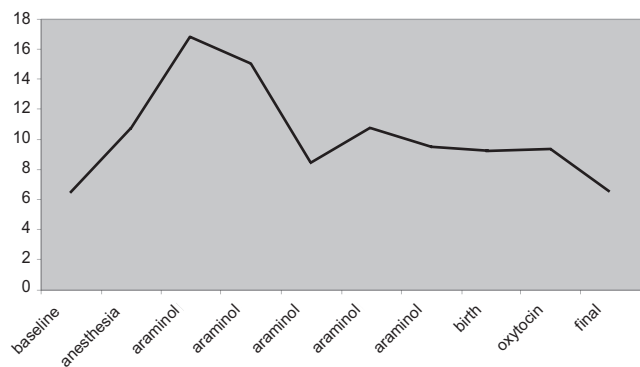
This is a 27-year old female, 89 kg, 162 cm, gesta 1, with diagnosis of a single fetus pregnancy on pelvic presentation, in labor, with indication of cesarean section. She was classified as physical status (ASA) II, since she had gestational

diabetes controlled with diet. The case developed according to that described in "methods", and her measurements are shown in Table II.

**Table II – Case 2 Measurements**

	CO	MAP	HR
Baseline	6.5	97	67
Anesthesia	10.8	106	91
Araminol	16.9	79	111
Araminol	15.0	76	107
Araminol	8.5	78	97
Araminol	10.8	70	94
Araminol	9.5	77	88
Birth	9.2	100	87
Oxytocin	9.3	95	81
Final	6.5	90	82

CO: Cardiac Output in L.min<sup>-1</sup>; MAP: Mean Arterial Pressure in mmHg; HR: Heart Rate in beats.min<sup>-1</sup>.



**Figure 2 – CO in L.min<sup>-1</sup> in Case 2.**

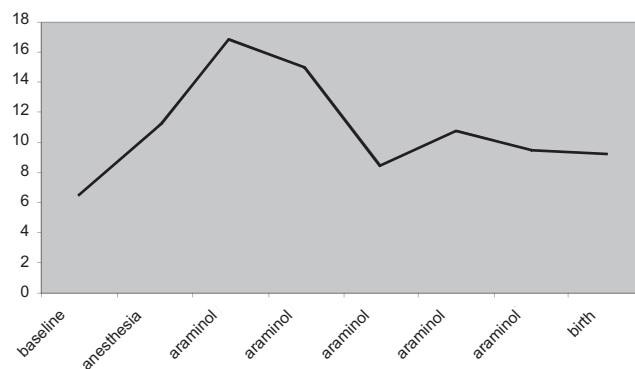
**CASE 3**

This is a 31-year old female, 106 kg, 179 cm, gesta 2, with a history of cesarean section, classified as ASA II, with a diagnosis of gestational diabetes controlled with diet, controlled systemic lupus erythematosus, fetal macrosomia, and iterativeness, and cesarean section was indicated. Measurements obtained after the onset of the surgery are shown in Table III.

**Table III – Case 3 Measurements**

	CO	MAP	HR
Baseline	8.4	114	73
Anesthesia	8.8	95	90
Araminol	7.4	92	61
Araminol	7.9	105	71
Birth	8.4	87	73
Oxytocin	8.7	70	79
Araminol	5.4	102	73
Final	7.4	104	70

CO: Cardiac Output in L.min<sup>-1</sup>; MAP: Mean Arterial Pressure in mmHg; HR: Heart Rate in beats.min<sup>-1</sup>.



**Figure 3 – CO in L.min<sup>-1</sup> in Case 3.**

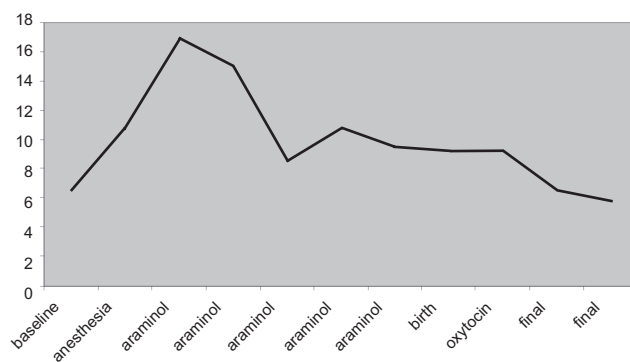
**CASE 4**

This is a 32-year old female, 63 kg, 149 cm, physical status ASA I, gesta 2, with a history of cesarean section, with a diagnosis of twin pregnancy in which one fetus was on pelvic presentation, with indication for cesarean section. Measurements are shown in Table IV.

**Table IV – Case 4 Measurements**

	HR	MAP	HR
Baseline	6.7	101	75
Anesthesia	6.4	103	88
Araminol	7.0	95	94
Araminol	5.3	93	70
Araminol	5.5	92	71
Araminol	4.1	91	65
Araminol	6.4	100	70
Birth	6.4	84	86
Oxytocin	7.8	79	100
Araminol	3.1	97	43
Final	5.7	93	64

CO: Cardiac Output in L.min<sup>-1</sup>; MAP: Mean Arterial Pressure in mmHg; HR: Heart Rate in beats.min<sup>-1</sup>.



**Figure 4 – CO in L.min<sup>-1</sup> in Case 4.**

## DISCUSSION

In general, the behavior of hemodynamic variables observed during interventions in patients undergoing cesarean sections under spinal anesthesia was:

1. After installation of the blockade, a fall in MAP with occasional elevation of HR and CO is observed;
2. When using the vasopressor metaraminol, a predominantly alpha-agonist drug, an increase in MAP with fall in HR and CO is observed;
3. When the fetus is extracted, the behavior is not uniform, with occasional elevation of CO and fall in MAP;
4. After infusion of oxytocin, marked changes are observed, such as fall in MAP besides an increase in HR and CO.

In case 1, after the blockade, measurements are close to baseline possibly because the sympathetic blockade did not achieve its peak or the effectiveness of conservative measures like dislocation of the uterus to the left and co-hydration. Unlike cases 2 and 4, who presented initially a compensatory increase of CO secondary to an increase in HR without compromising the BP, but which later manifested with a significant fall in BP. Since the beginning, case 3 showed significant hemodynamic changes with fall in MAP and increase in HR and CO. In response to the fall in MAP, boluses of the alpha-agonist vasopressor metaraminol were used, resulting in a typical response<sup>18</sup>, with an increase in MAP and fall in HR and CO, most likely due to an increase in afterload, except in case 2 in which only after fetal extraction a recovery in MAP was observed. Regarding delivery, in all cases, only after fetal extraction a similar response was observed with an increase in CO, which can be explained by self-transfusion resulting from uterine involution and contraction, as well as reduction in aortocaval compression, which increased preload. Oxytocin has vasodilator actions, with fall in MAP and increase in HR and CO, which were observed in all cases except in case 2. At the end, parameters returned to baseline levels most likely due to all interventions with less intense actions. The behavior of MAP demonstrated that its variations, most likely

due to changes in systemic vascular resistance (SVR), are secondary to vasodilator (spinal anesthesia and oxytocin) and vasoconstrictor (metaraminol) actions of interventions performed during cesarean sections that affect arterial tonus and not due to bleeding. Regarding the absence of SVR measurements as a limiting factor of this study, we decide not to use it, since it is an invasive measurement because it requires a right atrium catheter to measure pressure, which is required to its calculation.

Therefore, physiologic situations are observed, such as aortocaval decompression after birth and self-transfusion of uterine blood, that impose a great overload on the cardiovascular system with an increase of venous return, which is accommodated through the cardiac valves and pulmonary blood vessels. However, this may be a problem in patients with low cardiovascular reserve or with cardiopathies, such as mitral and aortic stenosis, besides pulmonary hypertension, resulting in pulmonary edema or cardiac failure. The same can be seen in situations that are induced like spinal anesthesia and oxytocin infusion in which normal patients respond with an increase in CO and fall in SVR and venous return, but in cardiopathies, these responses should be controlled or even avoided.

This cardiac output monitor produced data compatible with those of prior publications<sup>3,6,8,18,19</sup>, and in this scenery, external calibration with data obtained by thermodilution or lithium dilution was dispensable, especially when analysis is made based on tendencies and nominal values and not absolute values. Measurements produced can orient regarding a possible cause of hemodynamic changes and indicate the most appropriate treatment for the case, besides signaling reckless conducts, such as rapid infusion of oxytocin. They can also be useful in patients with limited cardiovascular reserve, since they cannot tolerate significant changes in SVR and they cannot compensate for changes in CO.

To conclude, it is a fact that HR, BP, and the communication with the awoken patient assessing her well-being are important parameters and the most commonly used in obstetric anesthesia. However, the minimally invasive uncalibrated CO monitors can have an important role in hemodynamic management of gravidas, especially high-risk gravidas with associated comorbidities<sup>4</sup> or as a research tool.