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High spinal anesthesia combined with general anesthesia versus general anesthesia alone : a retrospective cohort study in cardiac surgical patients

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Abstract : *Background :* Spinal anesthesia using intrathecal opioids alone does not offer significant benefits in cardiac surgery. Spinal anesthesia with local anesthetics blunts the stress and inflammatory response to cardiac surgery but has not been widely used. We report our experience with high spinal anesthesia in cardiac surgery in the setting of a "fast track" practice.
Methods : A retrospective matched cohort study comparing cardiac surgery patients having spinal anesthesia combined with general anesthesia compared to a control group having general anesthesia alone, conducted at two university hospitals between 2000 and 2010. Control patients were matched for age, sex, procedure, date, surgeon, site of operation and ejection fraction. Pre-specified data was abstracted.
Interventions : Spinal patients received intrathecal hyperbaric bupivacaine (0.75%), 39.6 ± 6.9 mg; morphine, 268 ± 54 µg plus a general anesthetic.
Results: 331 patients had surgery with spinal anesthesia. 331 matched controls were identified. Both groups were well matched for pre-determined variables. More spinal patients were extubated in the operating room (60.4% vs 43.2%, $p = 0.001$). Spinal patients required less opioids postoperatively (morphine equivalents, 18.5 mg vs 40,8 mg $P < 0.001$). There was no difference in ICU or hospital length of stay, return for bleeding or in-hospital mortality. No spinal patients required ICU readmission (0 vs 2.4%, $p = 0.004$). There were no spinal-related complications.
Conclusions : Spinal anesthesia improved post-operative recovery of cardiac surgical patients as manifested by earlier extubation, less opioid consumption and fewer ICU readmissions. Spinal anesthesia may be a method to augment enhanced recovery programs after cardiac surgery, which should be evaluated in prospective studies.

Key words : fast track anesthesia, spinal anesthesia, cardiac surgery, early extubation, postoperative analgesia, enhanced recovery.

Introduction

Enhanced recovery after surgery (ERAS) programs have been implemented and evaluated in a variety of surgical programs including colorectal surgery, gynecological surgery and liver resection surgery among others. Generally, ERAS protocols have resulted in shorter hospital lengths of stay, by 30% to 50%, fewer complications, no increase in hospital re-admission rates and decreased hospital costs. ERAS protocols also result in a decreased stress response to surgery. Most protocols emphasize minimally invasive surgery, early feeding and mobilization among other factors. Regional anesthesia techniques are an important part of many ERAS protocols, especially when open surgery is required (1-4).

Cardiac surgery and cardiac anesthesia were pioneers in ERAS programs with "fast track" anesthesia protocols in which early extubation of cardiac surgical patients resulted in decreased pulmonary complications, shortened ICU and hospital lengths of stay and reduced costs without increasing patient morbidity or mortality. Indeed, "fast track" anesthesia continues to be the standard for current cardiac anesthesia (5-7).

High spinal anesthesia using local anesthetics as a supplement to general anesthesia was first

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described in a case series published in 1994 (8).This practice has subsequently been adopted by a number of cardiac anesthesiologists at our institution and elsewhere in Canada. Studies have demonstrated that high spinal anesthesia blunts the stress response to surgery and cardiopulmonary bypass and enhances the anti-inflammatory response to cardiac surgery (9, 10). One study has demonstrated that spinal anesthesia with local anesthetics, is associated with a decreased risk of delirium in patients addicted to narcotics and undergoing cardiac surgery (11).

High spinal anesthesia combining both local anesthetics and intrathecal opioids has the potential to further augment "fast track" anesthesia protocols. As the average age and risk profile of patients continues to increase (12), spinal anesthesia may prove to be a simple but useful adjuvant to improve the recovery after cardiac surgery. This paper compared the outcomes of patients who had high spinal anesthesia in cardiac surgical procedures with that of appropriately matched control patients, at two tertiary care hospitals over a ten-year period.

Methods

Local institutional Research and Ethics Board approval was obtained. Data were derived from a province-wide data repository which houses several provincial clinical and administrative databases within the Population Health Research Data Repository. Separation Abstracts data provided information about an individual's initial cardiac surgery hospitalization and any subsequent re-hospitalization. Medical Claims (Physician Billings) data were examined to document the degree of interaction a patient had with his/her physician following discharge. Health data comprise records of all interactions in a single-payer healthcare system and include hospital discharge abstracts and physician billings. Individual-level linkages across data sets use encrypted unique identification numbers to preserve privacy and confidentiality. The validity and utility of the information in the repository has been well documented (13, 14). The years 2000 to 2010 were chosen to include those years where spinal anesthesia in cardiac patients was used more routinely by specific anesthesiologists, providing adequate sample size for analysis.

Patients who had cardiac surgical procedures with high spinal anesthesia during the time period 2000 to 2010 were identified using the anesthesia billing code for intrathecal opioid administration in conjunction with the billing codes of common cardiac surgical procedures. These included coronary arterial bypass grafting (CABG) only, aortic valve replacement (AVR) only, mitral valve replacement (MVR) only, or combination CABG with AVR or MVR or both, and combination AVR plus MVR without CABG.

The technique for spinal anesthesia is as follows. After insertion of the arterial line, the patient is placed in a lateral position, with the operating room table tilted head down between 10 to 15 degrees. The spinal is administered in a lumbar interspace and hyperbaric bupivacaine is used. All patients received preservative free morphine and some patients also received preservative free sufentanil at the discretion of the attending anesthesiologist. All drugs were mixed in one syringe. The combination of hyperbaric bupivacaine and the head down position ensures the local anesthetic will reach high thoracic (T2) dermatomes. After the spinal is administered, the patient is turned supine and general anesthesia is induced and the patient is intubated. The patient is kept in a head down position during the surgical preparation phase and the bed is leveled for surgical incision. Again, the head down position enhances venous return and helps to maintain hemodynamic stability with the extensive sympathetic blockade induced by the spinal anesthetic.

There was no standardized general anesthetic for patients. However, most patients received propofol for induction. Rocuronium was used as muscle relaxant. Anesthesia was maintained with sufentanil 1 to 2 µg/kg and either sevoflurane or isoflurane. Either morphine or hydromorphone was used for post bypass analgesia. The end tidal gas concentrations of the anesthetic agents used are lower in the spinal patients although this data could not be collected retrospectively.

For each high spinal anesthesia patient up to three potential control patients were identified as those who had the same operation without intrathecal administration of opioid over the same time period. Subsequently controls were matched with spinal patients using the following criteria: age (± five years), sex, procedure, date (± six months), site (two hospitals) socioeconomic status and treatment for hypertension and /or diabetes. These criteria were matched using the provincial administrative database (Appendix 1). Via chart review, control patients were then matched for cardiac ejection fraction and surgeon.

Once an appropriate cohort of spinal patients and control patients were identified, data was extracted from patient charts using an *a priori* data collection form approved by the Research and Ethics Board. The primary outcome variable evaluated was time to extubation. We recorded whether the patient could be extubated in the operating room at the end of the case as well as the duration of postoperative ventilation. Secondary outcome variables included postoperative analgesic administration, ICU and hospital length of stay (LOS), and common complications associated with cardiac surgery such as bleeding complications, respiratory complications, atrial fibrillation, vaso-pressor requirements, post-operative renal function, glucose management, stroke and wound infection. Statistical analyses were conducted using GraphPad Prism 6.05. Either the Chi square test or the Fisher's exact test were used for frequency analysis. It was determined that continuous dependent variables displayed skewedness and were not normally distributed. Therefore the non-parametric Wilcoxon rank sum test was used to compare between-group differences in continuous data. Multivariate logistic or linear regression models were used to adjust for potential confounding variables. In these analyses continuous dependent variables were log-transformed because of right skew. A p value < 0.05 was considered significant.

Results

From 2000 to 2010, 4,031 patients were identified from the administrative data base with the prespecified surgical procedures. We identified 377 patients who had cardiac surgical procedures with high spinal anesthesia over the ten-year period. Only 331 of these patients could be matched with control patients over the same period. This is shown in the Consort flow diagram in Figure 1. Demographic data on the two groups is shown in Table 1.

The two groups were well matched for the pre-determined matching variables (Table 1) There were some differences in those variables that were not specifically matched for, with spinal patients having a higher incidence of preoperative chronic obstructive lung disease (COPD) (12.7% vs 5.1%, $p = 0.001$), congestive heart failure (22.7% vs 14.2%, $p = 0.007$) peripheral vascular disease (10.6% vs 5.1%, $p = 0.013$), and urgent/emergent cases (15.7 % vs 7.2%, $p = 0.001$) (Tables 1 and 2). Intraoperatively, there was no difference in cardio-pulmonary bypass times or aortic cross clamp duration, however there was less insulin usage and lower peak blood glucose levels in the spinal group (Table 2).

Hyperbaric bupivacaine 0.75% with dextrose was used for the spinal anesthetic. The average bupivacaine dose was 39.6 ± 6.9 mg with a range of doses from 30 to 45 mg. All patients received preservative free morphine in the spinal, average dose 268 ± 54 µg. 56 patients (16%) also received sufentanil, average dose 26 ± 6 µg intrathecally, in addition to the morphine at the discretion of the attending anesthesiologist. There were four attending anesthesiologists who used spinal anesthesia, whereas there were twenty

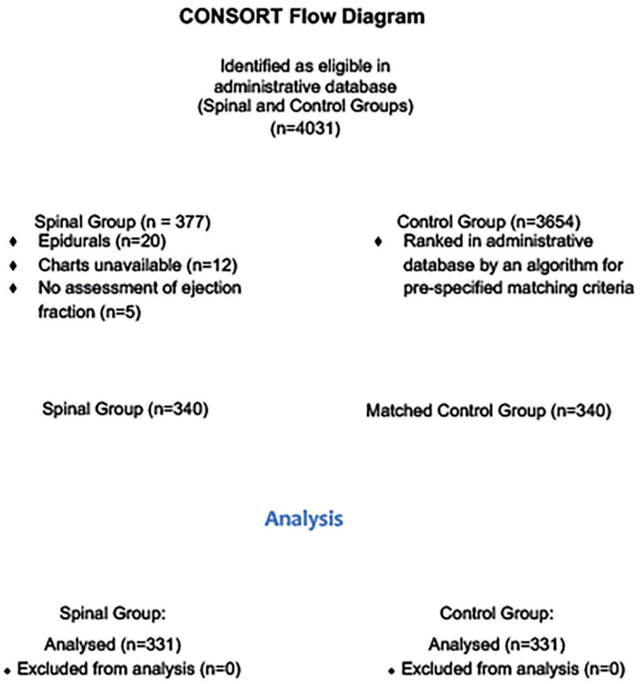

Fig. 1.

Table 1

Patient Demographics

Variable	Spinal Group	Control Group	P value
n	331	331	
Age (years)	66.0 [16.0]	67.0 [15.0]	0.91
Male	255 (78.0)	258 (77.9)	0.85
Female	76 (23.1)	73 (22.1)	
Body Mass Index	28.7 [6.1]	28.7 [5.9]	0.89
Ejection Fraction (%)	57.0 [15.0]	60.0 [12.0]	0.64
Angina	221 (66.8)	218 (65.9)	0.87
Prior Myocardial Infarction	139 (42.0)	158 (47.7)	0.16
Hypertension	231 (69.8)	219 (66.2)	0.36
Congestive Heart Failure	75 (22.7)	47 (14.2)	0.007
COPD	42 (12.7)	17 (5.1)	0.001
Diabetes	90 (27.1)	90 (27.2)	1.00
Pack-Years Smoking	30.0 [20]	30.0 [20]	0.14
Pulmonary Hypertension	12 (3.6)	5 (1.5)	0.14
Atrial Fibrillation	95 (28.7)	89 (26.9)	0.66
PVD	35 (10.6)	17 (5.1)	0.013
OSA	9 (2.7)	9 (2.7)	1.00
Stroke or TIA	20 (6.0)	27 (8.2)	0.36
Beta blockers	239 (72.2)	231 (69.8)	0.54
ASA	257 (77.6)	257 (77.6)	1.00
Statin	210 (63.4)	203 (61.3)	0.63
Calcium Channel Blockers	98 (29.6)	93 (28.1)	0.73
Ace-Inhibitors	197 (59.5)	189 (57.1)	0.58
Diuretics	95 (28.7)	97 (29.3)	0.93
Creatinine (μmol/L)	89.0 [30.5]	85.0 [25.0]	0.11
Glucose (mmol/L)	6.0 [2.7]	6.2 [2.5]	0.48
Hemoglobin (g/L)	140.0 [22.0]	140.0 [21.0]	0.61

Data are shown as median [interquartile range] or n (%). COPD : Chronic obstructive pulmonary disease ; PVD : Peripheral vascular disease ; OSA : Obstructive sleep apnea ; TIA : Transient ischemic attack ; ASA : Acetylsalicylic acid.

anesthesiologists providing general anesthesia in the control group. There were 12 surgeons in two hospitals performing the majority of surgeries. The distribution of surgeons was well matched between the two groups, with the exception of one surgeon (15% vs 9% p = 0.03).

It was observed that spinal anesthesia patients more frequently had pre-existing COPD, congestive heart failure, peripheral vascular disease and urgent/emergent case status (Table 1). To adjust for the potential confounding effect of these variables on the significantly increased transfusion rates, increased chest tube output and lower nadir hemoglobin values in the spinal group (Table 3), multivariable regression models were constructed. In these models, spinal anesthesia was no longer significantly associated with transfusion (p = 0.19) and lower nadir hemoglobin (p = 0.31), but remained significantly associated with increased chest tube output (p = 0.007)

Table 2

Intra-operative Data

Variable	Spinal Group	Control Group	P value
n	331	331	
Surgical Procedure			0.99
CABG 1 or 2 Vessels	38 (11.6)	43 (13.2)	
CABG 3 Vessels	108 (32.8)	106 (32.5)	
CABG 4 Vessels	64 (19.5)	63 (19.3)	
CABG > 5 Vessels	15 (4.6)	16 (4.9)	
One Valve	54 (16.4)	49 (15.0)	
Two Valves	3 (0.91)	5 (1.5)	
CABG + 1 valve	44 (13.4)	42 (12.9)	
CABG + 2 valves	3 (0.9)	2 (0.6)	
Mitral Valve	33 (10.0)	32 (9.7)	1.00
Aortic Valve	78 (23.6)	74 (22.4)	0.78
Elective Procedure	279 (84.3)	307 (92.7)	0.001
Urgent/Emergent Procedure	52 (15.7)	24 (7.2)	0.001
Resternotomy	3 (0.9)	0.0	0.25
Hospital A	197 (59.5)	195 (58.9)	1.00
Hospital B	134 (40.5)	136 (41.1)	
CPB Time (minutes)	95.0 [59.0]	91.0 [72.3]	0.56
Aortic XC Time (minutes)	61.0 [49.0]	59.0 [51.5]	0.78
Intrathecal Bupivacaine (mg)	45.0 [15]	NA	
Highest Glucose (mmol/L)	8.4 [2.6]	9.2 [2.3]	0.001
Required Insulin Infusion	81 (24.4)	125 (37.8)	0.001

Data are shown as median [interquartile range] or n (%). CABG : Coronary artery bypass graft ; CPB : Cardiopulmonary bypass ; XC : Cross-clamp.

Table 3

Post-operative Results

Variable	Spinal Group	Control Group	P value
n	331	331	
ICU admission	218 (64.1)	211 (63.7)	0.92
ICU LOS (days)	1.0 [1.0]	1.0 [1.0]	0.26
Hospital LOS (days)	6.0 [3.0]	6.0 [3.0]	0.30
Discharged Home	299 (90.6)	306 (92.7)	0.40
Extubated in OR	200 (60.4)	143 (43.2)	0.001
Post-operative ventilation (h)	6.2 [12.3]	8.5 [12.0]	0.25
Ventilation >24 h	17 (5.2)	18 (5.4)	1.00
Re-intubation	26 (7.9)	18 (5.4)	0.27
Re-admission to ICU	0	8 (2.4)	0.008
Reoperation for Bleeding	21 (6.3)	14 (4.3)	0.30
In-hospital Mortality	5 (1.5)	4 (1.2)	0.99
Inotrope/Vasopressor at 12 h	119 (36.0)	102 (31.1)	0.19
Inotrope/ Vasopressor at 24 h	69 (20.9)	63 (19.0)	0.56
Atrial Fibrillation	95 (28.7)	89 (26.9)	0.66
Renal Failure requiring Dialysis	4 (1.2)	3 (0.9)	0.99
Myocardial Infarction	5 (1.5)	2 (0.6)	0.45
Stroke or TIA	11 (3.3)	7 (2.1)	0.47
Sternal Infection	1 (0.3)	2 (0.6)	1.00
Pneumonia	14 (4.2)	8 (2.4)	0.28
Highest Creatinine (μmol/L)	97.0 [43.0]	93.0 [33.0]	0.06
Lowest Hemoglobin (g/L)	83.0 [24.0]	84.0 [26.0]	0.04
Chest Tube Output at 24h (L)	0.8 [0.7]	0.8 [0.6]	0.02
Peak Troponin (μg/L)	0.5 [0.8]	0.5 0.8]	0.48
Transfusion Required	154 (46.5)	124 (37.5)	0.015
Total RBC Transfused (units)	3.0 [3.0]	2.0 [3.0]	0.61

Data are shown as median [interquartile range] or n (%). ICU : Intensive Care Unit ; LOS : Length of stay ; TIA : Transient ischemic attack.

Table 4

Postoperative Analgesics

Variabl	Spinal Group	Control Group	P Value
n	331	331	
Opiates			
Total Cumulative Dose in			
1st 24h (M.E.)	16.0 [17.1]	33.5 [27.1]	<0.001
Percent of Patients (n)	96 (316)	98 (326)	0.04
Acetaminophen			
Total Cumulative Dose in			
1st 24h (mg)	2400 [2400]	3050 [2450]	<0.001
Percent of Patients (n)	82 (272)	79 (261)	0.33

A higher percentage of the spinal patients were extubated in the operating room at the conclusion of the case (60.4% vs 43.2%, p = 0.001). This gave an odds ratio for patients who had a spinal anesthetic, of being extubated in the operating room of 1.92 [95% confidence interval, 1.39 to 2.66]. In those patients who remained intubated at the end of the operation, there was no difference in the median [interquartile range] duration of postoperative ventilation (spinals, 6 [3-15] hours vs controls, 8.5 [4-16] hours p = 0.25).

With regards to ICU length of stay, the analysis was stratified by hospital, because there were different postoperative care pathways between the two hospitals. At hospital A, all cardiac surgical cases were admitted directly to the ICU postoperatively. Hospital B utilized a fast track protocol where patients recovered in the general post anesthesia care unit (PACU) for a four to eight hour period and were then transferred to a cardiac surgical step down unit. If patients at hospital B required vasopressors, inotropes or mechanical ventilation, they were admitted to the ICU. 390 cases were done at hospital A and 272 cases at hospital B (Table 2). At hospital B, 122 spinal patients and 120 control patients did not require ICU admission at any time during their hospital stay. The median, ICU length of stay at hospital A was 1.0 days [1.0-2.0] for the spinal group and 1.0 days [1.0-2.0] for the controls. There was no observed difference in the number of patients who bypassed ICU, nor in the ICU length of stay between groups (Table 3).

There was a marked difference in post-operative analgesic requirements with the spinal patients receiving less opioids and less acetaminophen (Table 4).

With regards to other post-operative outcomes, there was no difference between groups in hospital length of stay, re-intubation rate, return to the operating room for post-operative bleeding or in-hospital mortality. No spinal patients required readmission to the ICU, whereas 8 control patients (0 vs 2.4%, p = 0.004) were re-admitted to ICU.

The reasons for readmission to the ICU of the control patients were as follows: four patients were readmitted with respiratory failure from atelectasis and pneumonia. Two patients had reoperations for delayed post-operative bleed and tamponade. One patient had a low cardiac output state from a perioperative infarction. One patient had an acute kidney injury and needed readmission for treatment of high potassium.

Discussion

In this retrospective review, spinal anesthesia for cardiac surgery was associated with improved post-operative recovery as manifested by earlier extubation, less administration of opioids and fewer ICU readmissions. This was despite the fact that spinal patients were a higher risk population than the matched controls, with more patients with a history of congestive heart failure, COPD, peripheral vascular disease and more urgent/emergent cases.

A higher proportion of spinal patients were extubated in the operating room. Earlier extubation occurred despite that “fast track” anesthesia is standard at our institution. The “fast track” practice at our institution is clearly demonstrated by the high rate of extubation in the operating room for both groups (60% and 43%) and the large percentage of patients at hospital B, who were never admitted to an ICU postoperatively. Early extubation has been consistently associated with better post-operative outcomes (5-7). These extubation rates are higher than the 29% reported in a recent paper with a program geared to operating room extubation (15).

Spinal patients required less medication for postoperative analgesia. Although pain scores were not assessed, it is reasonable to assume the spinal patients had less pain. A critical feature of any ERAS protocol is multimodal analgesia (1-4). Intrathecal morphine has been used with success in certain ERAS programs.

The spinal group demonstrated lower blood glucose levels and less insulin usage. This may represent blunting of the stress response where lower cortisol and epinephrine levels may result in a lower glucose level. Blockade of the stress response has been shown with both spinal anesthesia and thoracic epidurals (9, 16). In reviewing ERAS protocols, a consistent finding has been a decreased stress response resulting in increased insulin sensitivity and attenuation of the breakdown of muscle protein (4). By attenuating the stress response, with lower cortisol and catecholamine levels, spinal anesthesia can potentially modulate perioperative insulin sensitivity.

There were no readmissions to ICU in the spinal group with eight readmissions in the control group of whom four had primary respiratory failure. This difference was found in spite of more spinal patients having a history of COPD. Regional anesthesia has consistently been shown to improve postoperative pulmonary function and decrease respiratory complications (17-19).

Most reports involving spinal anesthesia in cardiac surgery have only used intrathecal opioids. This provides better post-operative analgesia but no effects on the stress response or other complications (20, 23). The studies by Chaney et al using intrathecal morphine, 10 micrograms/kg, demonstrated an increase in post-operative ventilation time (21, 22). Studies with lower doses of intrathecal morphine, showed improved pain scores, alertness and shorter ICU times (23-26).

High spinal anesthesia as practiced at our institution uses intrathecal local anesthetics and opioids. Local anesthetics block nociceptive impulses intraoperatively resulting in a decreased stress response and modulation of the inflammatory response to surgery (8, 9). The intra-operative blockade of nociceptive stimuli may contribute to a degree of pre-emptive analgesia. Intrathecal morphine provides prolonged post-operative analgesia as has been demonstrated in other surgical procedures (25-27). There are concerns with the risk of hypotension from inducing such an extensive sympathetic blockade. In fact, this technique provides surprising hemodynamic stability. A head down position promotes cephalad spread of the block, limits venous pooling in the lower extremities and attenuates the contribution of decreased venous return to spinal induced hypotension.

The blood pressure is easily maintained with phenylephrine. In a prior study, there was more phenylephrine used in the spinal group before cardiopulmonary bypass but no difference in phenylephrine requirements during and after bypass between groups (9). Some patients also received sufentanil, intrathecally. Short acting opioids improve intraoperative analgesia in procedures done under spinal anesthesia(28-30).

A potential complication with the use of regional anesthesia in cardiac surgery is the risk of epidural hematoma (31-33). The use of spinal anesthesia is dependent on the attending anesthesiologist. Risks are discussed with the patient who must agree with the anesthetic plan, although no written consent is obtained. In non-cardiac surgery, the risk of hematoma with spinal anesthesia has been estimated at about 1 in 200,000 as compared to epidurals, which have an estimated incidence of 1 in 20,000 (34). In our clinical practice, the timing of heparin administration for cardiopulmonary bypass is usually between 1 to 2 hours after the spinal injection. ASRA guidelines suggest at least a one hour interval between dural puncture and heparin administration (35). This is based on expert opinion. A study has reported 466 children who had neuraxial anesthesia prior to cardiopulmonary bypass, where the interval between spinal and heparin administration was less than 60 minutes, with no adverse neurological sequelae(36). There have not been any complications associated with spinal anesthesia at our institution, but the numbers of patients are still too small to allow for any definitive comment on safety.

We also observed lower nadir hemoglobins and an increased need for transfusion in the spinal group, but these were no longer significant in multivariable analyses. We did find increased chest tube drainage in the spinal group in both univariable and multivariable analyses, but the clinical importance of this difference is uncertain.

Limitations

This study has several limitations. It is a retrospective review of a clinical practice, spinal anesthesia, used by certain anesthesiologists. Thus, there may be confounding factors, which have not been accounted for. The spinal and control cohort matching was successful for pre-determined variables. There were differences between the two groups in certain unmatched preoperative variables (congestive heart failure, COPD, peripheral vascular disease. urgent/emergent cases) however, these were all higher in the spinal patients and did not translate into more complications. There were more urgent cases in the spinal group. Urgent cases were defined as patients who were initially admitted to hospital with an acute coronary event and who were then kept in hospital until the necessary cardiac surgery was done. When these confounding variables were controlled for, there was no difference in perioperative blood loss.

There were differences with the attending anesthesiologists between groups, with only four individuals using spinal anesthesia whereas 20 anesthesiologists were in the control group. However, the individual anesthesiologist has generally not been found to be a significant factor in clinical outcomes (37, 38). Nevertheless, even at our institution, spinal anesthesia continues to be used only by certain individuals. Other anesthesiologists have not used spinals primarily because of the potential risk of epidural hematoma.

There was no standardization of the anesthetic technique for either the spinal group or the control patients given the retrospective nature of this review.

As with all retrospective studies, it may not be possible to control for unknown associated factors.

Conclusions

Spinal anesthesia combining local anesthetics and intrathecal opioids improved post-operative recovery of cardiac surgical patients as manifested by earlier extubation, less opioid use and fewer ICU readmissions. Spinal anesthesia may be a method to augment enhanced recovery programs after cardiac surgery, which should be evaluated in prospective studies in our current patient population.

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Appendix 1

Results of Matching High Spinal Cohort with Control Group

Matching Variable	High Spinal Cohort	Top 3 Matches	Standardized Difference After Matching (%)
N	377	1131	
Age			
40-59	28.7%	29.1%	1.0
60-64	14.9%	14.6%	0.7
65-74	32.4%	32.0%	0.7
75 and older	24.1%	24.3%	0.4
Proportion Male	75.9%	75.9%	0.0
Surgery Type			
CABG, 1 vessel	1.9%	1.6%	2.1
CABG, 2 vessels	10.1%	9.2%	3.0
CABG, 3 vessels	31.0%	33.2%	4.6
CABG, 4+ vessels	24.9%	24.0%	2.3
Aortic Valve	10.6%	10.6%	0.0
Mitral Valve	4.5%	4.5%	0.0
Aortic + CABG	10.9%	10.9%	0.0
Mitral + CABG	4.2%	4.2%	0.0
Aortic + Mitral +/- CABG	1.6%	1.6%	0.0
Tricuspid +/- other		0.3%	
Year of Surgery			
2000	10.1%	10.0%	0.3
2001	3.7%	3.4%	1.9
2002	3.2%	3.5%	1.5
2003	11.7%	11.1%	2.0
2004	13.0%	11.6%	4.3
2005	9.3%	11.7%	7.8
2006	11.4%	12.3%	2.7
2007	13.8%	10.7%	9.4
2008	8.0%	10.7%	9.4
2009	7.7%	9.1%	5.1
2010	8.2%	6.1%	8.2
Vessel Count (CABG with no other procedures only)			
1	2.7%	2.3%	2.5
2	14.8%	13.5%	3.7
3	45.7%	48.8%	6.3
4+	36.7%	35.3%	3.0
Hospital			
St. Boniface	56.8%	74.5%	38.1
HSC	43.2%	25.5%	38.1
RHA			
IE	11.9%	11.8%	0.6
NO	5.3%	4.2%	5.0
SO	12.2%	12.2%	0.0
WE	13.5%	12.3%	3.7
WP	57.0%	59.5%	5.0
Income			
R1	8.5%	7.5%	3.6
R2	7.7%	6.6%	4.1
R3	6.4%	7.7%	5.2
R4	9.3%	9.6%	0.9
R5	8.5%	7.0%	5.7
U1	10.1%	10.4%	1.2
U2	12.5%	13.4%	2.6
U3	12.7%	14.4%	4.9
U4	13.8%	12.3%	4.5
U5	10.6%	10.9%	0.9
Unclassifiable	0.0%	0.3%	7.4
Comorbidities			
Percent with Diabetes	30.0%	30.5%	1.2
Percent with Hypertension	57.3%	58.3%	2.0

RHA – regional health authority