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Efficacy of Ondansetron as a Prophylactic Anti-Hypotensive Pharmacologic Intervention Among Obese Parturients Undergoing Spinal Anesthesia for Cesarean Delivery

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Abstract

Background and Purpose: Obesity is a risk factor for hypotension after spinal anesthesia among parturients undergoing cesarean delivery. Although researchers have demonstrated that prophylactic administration of ondansetron is efficacious in attenuating maternal hypotension following spinal anesthesia, no studies have examined the efficacy of prophylactic ondansetron in the high-risk population of obese parturients. The primary objective of this study was to assess the efficacy of the novel application of ondansetron as a prophylactic anti-hypotensive pharmacologic intervention among obese parturients to facilitate practice recommendations for reducing maternal-fetal risk associated with the administration of spinal anesthesia for cesarean delivery.

Methods: Retrospective chart analyses of 46 patients with a body mass index > 30 were conducted between August 1, 2014, and May 10, 2015, to determine whether the intravenous administration of 4 mg ondansetron before the induction of spinal anesthesia reduced the frequency of vasopressor administration during cesarean delivery.

Results: The incidence of vasopressor administration among patients who received prophylactic ondansetron was 35.7%, whereas 46.9% of patients who did not receive prophylactic ondansetron required vasopressor administration ($\chi 2 = 0.144$, df = 1, P = 0.704).

Conclusions: Obese parturients undergoing spinal anesthesia for cesarean delivery demonstrated improvements in hemodynamic stability when prophylactically treated with ondansetron.

INTRODUCTION

Background

Recognized as a pandemic nutritional disorder by the World Health Organization,[1] obesity has become one of the most critical global health issues. Obesity in the United States has been on the rise for more than 30 years despite the objectives of Healthy People 2000 through Healthy People 2020. In fact, prevalence estimates by the Centers for Disease Control and Prevention (CDC) indicate that more than one-third of the population of the United States is overweight (body mass index [BMI] of 25–29.9), while more than one-fourth of the population is obese (BMI of 30–99.8).[2] In 2012, Washington State reported that 35.4% of its residents were overweight and 26.8% of its residents were obese.[3] Among those surveyed in the 2011-2012 National Health and Nutrition Examination Survey, 34.9% of women were considered obese.[4] In alignment with this trend in population health is the statement by the CDC that "in the United States, obesity during pregnancy is common and it increases obstetrical risks."[5]

As obesity has increased in both incidence and prevalence in the general population, the rate of obesity in the obstetric population has correspondingly grown. Among the greatest contributing factors to anesthetic risk in pregnancy are the sequelae resultant from obesity.[5,6] Increased anesthetic risk is a result of the multisystemic physiologic changes associated with pregnancy. The most significant contributors to maternal mortality are the elevated physiologic demands on the respiratory and cardiovascular systems. Associated with serious morbidity, obesity in the parturient further increases anesthetic risk as well as the incidence of instrumental and cesarean deliveries.[5]

For the obese parturient, the subsequent necessitation of the administration of anesthesia additionally burdens the cardiovascular and respiratory systems. Tan and Sia stated, "The engagement of the obstetrical anesthetist in the management of this group of high-risk patients should be performed antenatally so that an appropriate management strategy can be planned in advance to prevent an adverse outcome."[7] Among the most common adverse outcomes observed in obese parturients undergoing spinal anesthesia for cesarean delivery is hypotension.[8] The sequelae resultant from hypotension among parturients are particularly worrisome as they include both maternal and fetal effects and occur at an incidence of 20% to 100%.[8] Serious maternal-fetal consequences secondary to hypotension include fetal hypoxia resultant from utero-placental insufficiency and an increased incidence of maternal nausea and vomiting secondary to hypoperfusion of the chemoreceptor trigger zone and vomiting centers within the medulla.[9] Therefore, Nani and Torres concluded in their study correlating the BMI of pregnant women with the development of hypotension after spinal anesthesia for cesarean delivery that anesthetic techniques should be improved to reduce the consequences of spinal-induced hypotension in both pregnant women and their fetuses.[8]

Prophylactic utilization of intravenous ondansetron has been identified as a mechanism by which to decrease anesthetic risk among parturients undergoing spinal anesthesia for cesarean delivery via the abatement of the Bezold-Jarisch reflex (BJR), with resultant improvements in hemodynamic stability including a decrease in the incidence of hypotension.[10,11] Through increased vagal tone, the BJR has been identified as a contributing factor to maternal hypotension following induction of spinal anesthesia. Characterized by bradycardia and worsening hypotension, the reflex is initiated by chemoreceptors in the left ventricle, identified as 5-hydroxytryptamine-3 (5HT3) receptors, in response to spinal anesthetic-induced systemic vasodilation and resultant relative hypovolemia.[12] Attenuation of the BJR may therefore decrease the incidence of severe refractory hypotension in obese parturients undergoing spinal anesthesia for cesarean delivery. As a result, reduction of anesthetic risk in this specific vulnerable population of obese parturients may be feasible.[10]

Significance

Many are affected by and invested in the health and well-being of pregnant patients with BMI > 30. As obesity is passed down from mother to child, the obesity epidemic continues to become more prevalent and more profound despite national efforts to address the issue. Stakeholders therefore include community health care systems, agencies, and providers who confront unique challenges associated with caring for obese parturients. Anesthetists are directly affected by the obesity pandemic given that elevated BMI is associated with increased perioperative risk.

The CDC[5] drew on the work of Chu et al[6] in finding that "obesity during pregnancy is associated with increased use of health care and physician services, and longer hospital stays for delivery." Cesarean delivery rates are also higher at 45.2% for extremely obese women versus 21.3% for nonobese women.[1] Delivery via cesarean incurs greater anesthetic risk and is associated with higher medical costs. In fact, the estimated annual medical cost of obesity in the United States was calculated to be $147 billion in 2008.[3] Compared with the nonobese population, medical costs for obese patients were $1429 higher per person.[13]

Literature Review

Ondansetron, when administered 5 minutes before a subarachnoid block, has been identified as an efficacious intervention to reduce the incidence of spinal anesthesia-associated hypotension for cesarean delivery. Sahoo et al[10] conducted a randomized controlled trial (RCT) that was later expanded upon by Wang et al.[14] The researchers demonstrated that 4 mg of ondansetron given intravenously 5 minutes before a subarachnoid block was effective in reducing the incidence of spinal anesthesia-associated hypotension during cesarean delivery. The researchers' purpose was to clearly define the effect of ondansetron on the hemodynamic response following spinal anesthesia for cesarean delivery, based on the physiologic effects of 5HT3 antagonists on the BJR. The BJR results in profound hypotension and bradycardia as a result of increased vagal tone due to stimulation of chemoreceptors in the left ventricle. A sample size of 52 parturients was randomized to 2 groups. One group received intravenous ondansetron; the other received normal saline before spinal anesthetic for cesarean delivery. Vital signs and vasopressor administration were recorded and quantified as outcome measures. The results revealed fewer hypotensive episodes and a resultant decrease in vasopressor administration in the ondansetron group ($P < 0.001$). Of the 26 parturients in the ondansetron group, 2 required vasopressor administration (7.69%). Of the 26 parturients in the saline group, 11 required vasopressor administration (42.31%). The absolute difference was a 34.62% decrease in vasopressor administration when ondansetron was administered prophylactically.[10] Compared with the results of the current study, a similar decrease in the frequency of vasopressor administration was observed in both the obese and the nonobese patient populations following initial doses of 4 mg ondansetron administered before spinal anesthesia.

Wang et al conducted a double-blind RCT that included 66 parturients scheduled for elective cesarean delivery. Five minutes before receiving spinal anesthesia, patients received ondansetron or saline. In addition to maternal hemodynamics, Wang et al analyzed umbilical cord blood samples after delivery to determine the incidence of fetal acidosis. Study findings included increased fetal pH as well as decreased incidence of maternal hypotension and nausea among those prophylactically treated with ondansetron.[14]

Chu and colleagues reported in the New England Journal of Medicine that higher BMI was related to increased rates of cesarean delivery and obesity-related high-risk conditions.[6] It is consequently more likely that an obese parturient will require the intervention of an anesthetist during labor and delivery as a result of the increased incidence of cesarean or instrumental delivery among such patients. Furthermore, owing to the increased incidence of obesity-related high-risk conditions during pregnancy, anesthetic risk is compounded. According to Cooper and McClure, complications directly related to anesthesia were deemed responsible for the deaths of 6 women in the United Kingdom, thereby demonstrating anesthesia as one of the leading causes of death among parturients.[15]

Numerous research studies over recent years have confirmed that obese parturients present even greater anesthetic risk than their nonobese counterparts.[8,16-22] Nani and Torres specifically addressed the incidence of hypotension after the administration of spinal anesthesia as it relates to BMI. The sample size for

normal-weight patients, as defined by a BMI less than 25, was 49. The sample size for the overweight group, as defined by a BMI greater than or equal to 25, was 51. The results reflected fewer episodes of hypotension in the non-overweight group. Confidence intervals of 5.89 ± 0.53 episodes versus 7.80 ± 0.66 episodes, with a P value of 0.027, were reported, compared with 5.36 to 6.42 episodes of hypotension following spinal anesthesia for cesarean in patients with BMI < 25. The P value was determined to be 0.027.[8]

Risk Versus Benefit

Researchers have demonstrated that anesthetic risk associated with spinal anesthesia-related hypotension among parturients undergoing cesarean delivery may be attenuated with the prophylactic administration of ondansetron.[10,14] Obese parturients undergoing spinal anesthesia for cesarean delivery have a higher incidence of severe refractory hypotension than do their nonobese counterparts.[8-22] Hence, the population that may benefit most from the application of prophylactic anti-hypotensive ondansetron administration is obese parturients. However, incorporation of such evidence into clinical practice by anesthesia providers has been slow and inconsistent. This may be due, in part, to the fact that the findings of current literature support the need for further evaluation of evidence-based practice recommendations for the specific population of high-risk obese parturients undergoing spinal anesthesia for cesarean delivery.

Ondansetron, a widely used anti-emetic and serotonin antagonist, has been safely used to blunt the BJR, resulting in less bradycardia and hypotension first in animals and later in humans undergoing a subarachnoid block.[10,14] Ondansetron is a selective serotonin antagonist specific to the 5HT3 receptor. Although initially designed to target 5HT3 receptors in the chemoreceptor trigger zone responsible for nausea and vomiting, the novel administration of ondansetron for the prevention of hypotension secondary to blockade of 5HT3 receptors in the left ventricle has shown potential for clinical utility in the prevention of hypotension and bradycardia associated with the BJR.[10]

Ondansetron is a drug commonly administered in hospital operating rooms throughout the United States for the prevention of postoperative nausea and vomiting. As such, it has a well-established safety record provided it is given within the recommended dose of 4 mg intravenous for adult patients and 0.1-0.15 mg/kg for pediatric patients. The primary side effects associated with ondansetron include asthenia, constipation, diarrhea, headache, and somnolence.[11] As with all pharmacologic interventions, judicious administration is recommended.

METHODS

Ethical Concerns

Institutional Review Board (IRB) exemption was obtained through Gonzaga University. Because the scholarly project was a retrospective, observational chart review, no patient informed consent was deemed necessary. Site support for the project was obtained by the Department of Anesthesia at our community hospital, the Hospital Administrator, and the Director of Health Information.

Setting

As of the last census data, the county studied was tied for the county with the second highest prevalence of obesity in Washington State. The city that was the focus of the study is rural, with a population of less than 8000, within this county. The Hispanic population of the city represents 61.4% of the total population, compared with 11.9% in Washington State. In addition, persons living below the poverty level in the city account for 22.9% of the population, compared with 13.4% statewide.[3] Of those undergoing a cesarean delivery at our community hospital in 2014 (n = 117), the majority, approximately 97%, were Hispanic. Hispanic ethnicity and higher rates of poverty are associated with higher rates of peripartum obesity.[23] Therefore, a retrospective chart review of obese parturients who necessitated spinal anesthesia for cesarean delivery was productive and efficacious in the assessment of ondansetron administration for the prevention of intraoperative hypotension at our community hospital. As a result, this study provided useful clinical information regarding the reduction of anesthetic risk in this specific vulnerable population[6] and will facilitate evidence-based practice recommendations.

Intervention

By use of a retrospective design, we analyzed medical records from parturients with a BMI greater than or equal to 30 who were admitted to the community hospital between August 1, 2014, and May 10, 2015, to determine whether the intravenous administration of 4 mg ondansetron prior to the induction of spinal anesthesia reduced the frequency of administration of vasopressors during cesarean delivery. Utilization of prophylactic ondansetron was based on current literature and had only been implemented into clinical practice at this institution as of August 2014. Therefore, August 1, 2014, was established as the start date for all data collection. Numerous data points were included in the chart review. Patient information included BMI, maternal age, gestational age, and ethnicity. Interventional information collected included time of initiation of spinal anesthetic, time of prophylactic ondansetron administration (if applicable), dose of 0.75% spinal bupivacaine with dextrose (milliliters) administered, dose of spinal morphine sulfate (milligrams) administered, time of initial vasopressor administration (if applicable), total ephedrine dose administered (if applicable), and total phenylephrine dose administered (if applicable). The same data were also collected and analyzed on the nonobese population for purposes of comparison. Data were analyzed from the charts of 3 different anesthesia providers.

Data Analysis

Descriptive analyses were conducted by using Excel software for Windows (Microsoft Corp) to synthesize and describe patient characteristics (age, BMI, ethnicity, and gestation) as well as frequency, mean, median, and mode of all data. A chi-square test was used to analyze whether the observed difference in the vasopressor requirements of the group of patients who received ondansetron and the group of patients who did not receive ondansetron was significant. An independent samples t-test was utilized to determine the statistical significance of the observed decrease in ephedrine dosing among patients who received prophylactic ondansetron versus those who did not.

Hypotension was considered significant and counted among the incidents included in the statistical analysis if it necessitated treatment as evidenced by administration of phenylephrine or ephedrine as documented on the anesthetic record. The total dose of vasopressor administration was recorded for each patient and subsequently compared between obese patients who did and did not receive ondansetron before the induction of spinal anesthesia.

RESULTS

Retrospective chart analysis of 46 patients with BMI > 30 at our community hospital between August 1, 2014, and May 10, 2015, revealed an 11.175% decrease in vasopressor administration among the 14 patients who received 4 mg IV ondansetron 5 minutes before spinal anesthesia for cesarean delivery compared with the 32 patients who were not treated with prophylactic ondansetron (Figure 1). Although not included in the study of obese parturients, data were collected from nonobese patients for the purposes of comparison. Among the 24 patients excluded from the chart review because of having a BMI < 30, 7 patients received prophylactic ondansetron. Of the nonobese patients who received prophylactic ondansetron, none required vasopressor administration intraoperatively, representing a substantial improvement in maternal hemodynamics. Of the 17 nonobese patients who did not receive prophylactic ondansetron, 47% required intraoperative vasopressor administration. However, this difference was not significant ($X^2 = 0.144$, $df = 1$, $p = 0.704$) (Table 1).

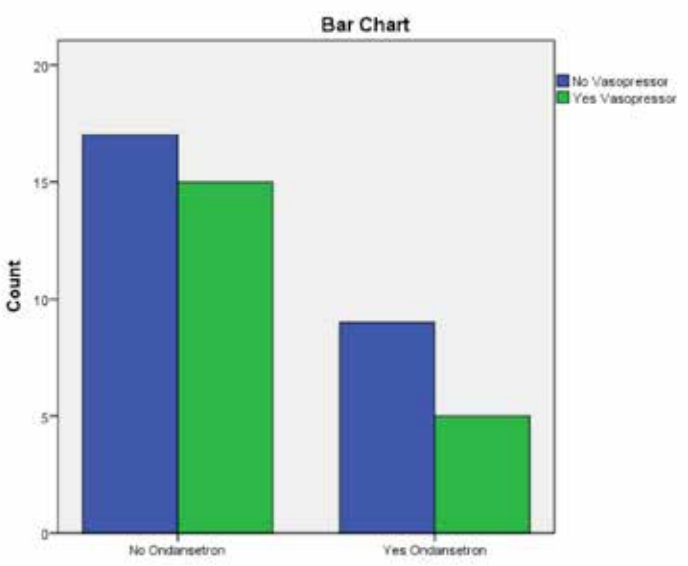

Figure 1. Ondansetron administration versus vasopressor administration.
Of 46 patients, 32 were not treated and 14 were treated with prophylactic ondansetron. The chart visually demonstrates the 11.175% decrease in the rate of vasopressor administration with the prophylactic administration of ondansetron.

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
Ondansetron 1=yes; 0=no * Vasopressor 1= yes; 0=no	46	100.0%	0	0.0%	46	100.0%

Ondansetron 1=yes; 0=no * Vasopressor 1= yes; 0=no cross tabulation

			Vasopressor 1= yes; 0=no		Total
			No Vasopressor	Yes Vasopressor	
Ondansetron 1=yes; 0=no	No Ondansetron	Count	17	15	32
		Expected Count	18.1	13.9	32.0
	Yes Ondansetron	Count	9	5	14
		Expected Count	7.9	6.1	14.0
Total		Count	26	20	46
		Expected Count	26.0	20.0	46.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.494[a]	1	.482		
Continuity Correction[b]	.144	1	.704		
Likelihood Ratio	.499	1	.480		
Fisher's Exact Test				.535	.355
Linear-by-Linear Association	.483	1	.487		
N of Valid Cases	46				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.09.

b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.104	.482
	Cramer's V	.104	.482
N of Valid Cases		46	

Table 1. Chi-square test tables

Chi-square test tables are presented to provide a summary of the statistical analysis of the efficacy of ondansetron administration in decreasing the incidence of vasopressor administration.

Only 3 obese parturients who received ondansetron required ephedrine administration, with a mean dose of 10 mg administered. Of the obese parturients not prophylactically treated with ondansetron, 14 required ephedrine administration, with a mean dose of 18.57 mg administered.

Similarly, only 2 obese parturients who received prophylactic ondansetron required phenylephrine, with a mean dose of 0.1 mg administered. Of the obese parturients not prophylactically treated with ondansetron, 1 required phenylephrine administration, with a dose of 0.05 mg administered.

An independent samples t-test revealed that there was not a significant mean difference in vasopressor administration dosage between those who received ondansetron (M = 10, SD = 5) and those who did not receive ondansetron (M = 18.57, SD = 7.45; $t(15) = 1.35$, $p > 0.05$) (Table 2).

Overall results showed a reduced pattern of vasopressor administration among obese women who received 4 mg IV ondansetron 5 minutes before receiving spinal anesthesia. However, when compared with women who did not receive ondansetron administration, the frequency of vasopressor administration did not significantly differ between the groups.

The average BMI for the obese patients included in the study was 36.97, compared with 27.55 for patients excluded from the study for being nonobese. The average maternal age was 30.06 years for the obese group and 29.833 for the nonobese group. The average gestational age was 38 weeks for the obese group, compared with 38.67 weeks for the nonobese group. Among the obese group, 39 (84.7%) were Hispanic, whereas 5 (10.8%) were white, and 2 (4.3%) were of other ethnicity (Figure 2).

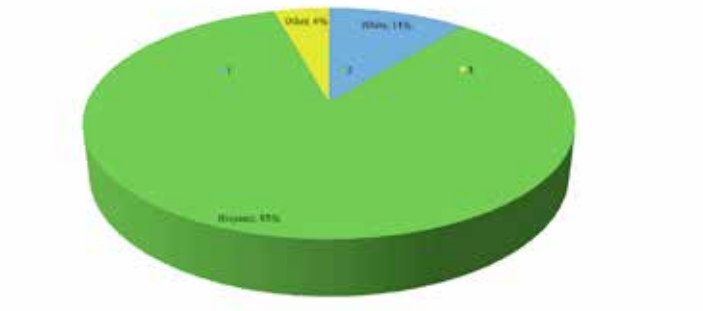

Figure 2. Demographic data on ethnicity.
Pictorial summary of the ethnicity of the 46 patients included in the study.

Group Statistics

	Ondansetron 1=yes; 0=no	N	Mean	Std. Deviation	Std. Error Mean
Ephedrine Dose (mg)	No Ondansetron	14	18.57	7.449	1.991
	Yes Ondansetron	3	10.00	5.000	2.887

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ephedrine Dose (mg)	Equal variances assumed	1.351	.263	1.879	15	.080	8.571	4.562	-1.153	18.296
	Equal variances not assumed			2.444	4.209	.068	8.571	3.507	-.977	18.120

Table 2. T-test tables

Group statistics and independent samples test summaries of ephedrine dosing following ondansetron versus no ondansetron is presented to provide a statistical summary of the data.

It is vital to examine the association between ondansetron administration and vasopressor administration in a larger sample of obese women in the future. It is challenging to detect a significant association between ondansetron administration and vasopressor administration in a limited sample size such as that used in the present study.[24-26]

DISCUSSION

Limitations

Although the results of the retrospective chart review demonstrated improvements in hemodynamic stability among obese parturients undergoing spinal anesthesia for cesarean delivery, the project was limited by a small sample size and a retrospective design. Future research should be conducted via prospective RCT with a larger sample size to provide definitive recommendations for practice change.

Additional limitations of this retrospective chart review included an inability to control for variances in fluid management, including volume of crystalloid or colloid pre-loading. Provider preference and threshold for vasopressor administration also impacted the results of the chart review and will be difficult to control in an RCT as well.

Implications for Practice

The findings from this retrospective analysis, although based on a small sample size, support the recommendation for routine prophylactic administration of 4 mg IV ondansetron 5 min before the administration of spinal anesthesia for cesarean delivery.

Considerations regarding differences in the apparent efficacy of ondansetron as a prophylactic anti-hypotensive pharmacologic intervention in obese versus nonobese groups are many. Obesity-related physiologic changes include increased aorto-caval compression secondary to increased weight, greater volume of distribution, and elevated preoperative fluid requirements. Pharmacologic considerations include weight-based dosing of ondansetron and the addition of colloids to crystalloids to maximize intravascular volume before the administration of spinal anesthesia among obese parturients.

Summary

As a result of this retrospective chart analysis, it has been demonstrated that the novel application of ondansetron as a prophylactic anti-hypotensive agent administered 5 minutes before the induction of spinal anesthesia may improve hemodynamic stability among patients with a BMI > 30 necessitating cesarean delivery. These findings are consistent with current recommendations for the nonobese population based on the extant medical literature. It may be possible to attenuate the maternal-fetal risk associated with the administration of spinal anesthesia in the vulnerable and ever-increasing population of obese parturients if this evidence-based practice is further established in a larger sample size in an RCT and with subsequent widespread adoption into anesthetic protocols.

REFERENCES

1. Obesity and overweight. World Health Organization website. http://www.who.int/mediacentre/factsheets/fs311/en. Version current 2012. Accessed March 17, 2015.
2. Behavioral Risk Factor Surveillance System 2013. Centers for Disease Control and Prevention website. http://www.cdc.gov/brfss/. Accessed March 22, 2015.
3. Levi J, Segal L, St. Laurent R, et al. F as in Fat: *How Obesity Threatens America's Future.* Princeton, NJ: Robert Wood Johnson Foundation; 2012.
4. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of obesity among adults: United States, 2011-2012. NCHS Data Brief no. 131. http://www.cdc.gov/nchs/data/databriefs/db131.pdf. Published October 2013. Accessed March 17, 2015.
5. Pregnancy complications. Centers for Disease Control and Prevention website. http://www.cdc.gov/reproductivehealth/maternalinfanthealth/pregcomplications.htm#n5. Version current 2014. Accessed March 11, 2015.
6. Chu SY, Bachman DJ, Callaghan WM, et al. Association between obesity during pregnancy and increased use of healthcare. *N Engl J Med*. 2008;358(14):1444-1453. http://dx.doi.org/10.1056/NEJMoa0706786.
7. Tan C, Sia AC. Anesthesia considerations in the obese parturigrava. *Semin Perinatal.* 2011;35(6):350–5, 350.
8. Nani F, Torres M. Correlation between the body mass index (BMI) of pregnant women and the development of hypotension after spinal anesthesia for cesarean section. *Rev Bras Anest.* 2011;61(1):21-30. http://dx.doi.org/10.1016/S0034-7094(11)70003-4.
9. Borgeat A, Ekatodramis G, Schenker CA. Postoperative nausea and vomiting in regional anesthesia. *Anesthesiology.* 2003;98(2):530-547. http://dx.doi.org/10.1097/00000542-200302000-00036.
10. Sahoo T, SenDasgupta C, Goswami A, Hazra A. Reduction in spinal-induced hypotension with ondansetron in parturients undergoing caesarean section: A double-blind, randomized, placebo-controlled study. *Int J Obstet Anesth*. 2012;21(1):24-28. http://dx.doi.org/10.1016/j.ijoa.2011.08.002.
11. Wang M, Zhuo L, Wang Q, et al. Efficacy of prophylactic intravenous ondanestron on the prevention of hypotension during cesarean delivery: A dose-dependent study. *Int J Clin Exp Med*. 2014;7(12):5210-5216.
12. Liu SS, McDonald SB. Current issues in spinal anesthesia. *Anesthesiology.* 2001;94(5):888-906. http://dx.doi.org/10.1097/00000542-200105000-00030.
13. Adult obesity facts. Centers for Disease Control and Prevention website. http://www.cdc.gov/obesity/data/adult.html. Accessed March 17, 2015.
14. Wang Q, Zhuo L, Shen MK, Yu Y-Y, Yu J-J, Wang M. Ondansetron preloading with crystalloid infusion reduces maternal hypotension during cesarean delivery. *Am J Perinatol.* 2014;31(10):913-922. http://dx.doi.org/10.1055/s-0033-1364189.
15. Cooper GM, McClure JH. Anaesthesia chapter from Saving Mothers' Lives; reviewing maternal deaths due to make pregnancy safer. *Br J Anaesth.* 2008;100(1):17-22. http://dx.doi.org/10.1093/bja/aem344.
16. Butwick A, Carvalho B, Danial C, Riley E. Retrospective analysis of anesthetic interventions for obese patients undergoing elective cesarean delivery. *J Clin Anesth*. 2010;22(7):519-526. http://dx.doi.org/10.1016/j.jclinane.2010.01.005.
17. Edomwonyi NP, Osaigbovo PE. Incidence of obesity in parturients scheduled for caesarean section, intra-operative complications, management and outcome. *East Afr Med J.* 2006;83(4):112-119. http://dx.doi.org/10.4314/eamj.v83i4.9425.
18. Horikawa Y, Fukuda H, Kawakami T, et al. The effect of obesity on spinal anesthesia for cesarean section. *Masui*. 2001;50(11):1205-1208.
19. Johnson D. Management of cesarean delivery in the morbidly obese woman. *Contemp Ob Gyn*. 2012;57(10):57-61. http://contemporaryobgyn.modernmedicine.com/contemporary-obgyn/news/modernmedicine/modern-medicine-feature-articles/management-cesarean-delivery
20. Rodrigues FR, Brandao MJ. Regional anesthesia for cesarean section in obese pregnant women: A retrospective study. *Braz J Anesthesiol.* 2011;61(1):13-20. http://dx.doi.org/10.1016/S0034-7094(11)70002-2.
21. Roofthooft E. Anesthesia for the morbidly obese parturient. *Curr Opin Anesth.* 2009;22(3):341-346. http://dx.doi.org/10.1097/ACO.0b013e328329a5b8.
22. Vricella L, *Louis J, Mercer B, Bolden N. Anesthesia complications during scheduled cesarean delivery for morbidly obese women. Am J Obstet Gynecol.* 2010;203(3):276.e1-276.e5. http://dx.doi.org/10.1016/j.ajog.2010.06.022.
23. US Department of Health and Human Services, Office of Disease Prevention & Health Promotion. Healthy People 2020 topics & objectives. http://healthypeople.gov/2020. Accessed June 27, 2016.
24. Campbell I. Chi-squared and Fisher-Irwin tests of two-by-two tables with small sample recommendations. *Stat Med*. 2007;26(19):3661-3675. http://dx.doi.org/10.1002/sim.2832.
25. Cochran WG. The 2 test of goodness of t. *Ann Math Stat.* 1952;23(3):315-345. http://dx.doi.org/10.1214/aoms/1177729380.
26. Fisher RA. The logic of inductive inference. *J Royal Stat.* 1935;98(1):39-54. http://dx.doi.org/10.2307/2342435