Anesthetic management for Cesarean delivery in parturients with a diagnosis of dwarfism

Prise en charge anesthésique d'un accouchement par césarienne chez des parturientes ayant un diagnostic de nanisme

Elizabeth M. S. Lange, MD · Paloma Toledo, MD, MPH · Jillian Stariha, BA · Heather C. Nixon, MD

Received: 18 January 2016/Revised: 27 March 2016/Accepted: 9 May 2016/Published online: 12 May 2016
© Canadian Anesthesiologists' Society 2016

Abstract

Purpose The literature on the anesthetic management of parturients with dwarfism is sparse and limited to isolated case reports. Pregnancy complications associated with dwarfism include an increased risk of respiratory compromise, an increased risk of Cesarean delivery, and an unpredictable degree of anesthesia with neuraxial techniques. Therefore, we conducted this retrospective review to evaluate the anesthetic management of parturients with a diagnosis of dwarfism.

Methods We used a query of billing data to identify short statured women who underwent a Cesarean delivery during May 1, 2008 to May 1, 2013. We then hand searched the electronic medical record for qualifying patients with heights < 148 cm and a diagnosis of dwarfism. The extracted data included patient demographics and obstetric and anesthetic information.

Results We identified 13 women with dwarfism who had 15 Cesarean deliveries in total. Twelve of the women had disproportionate dwarfism, and ten of the 15 Cesarean deliveries were due to cephalopelvic disproportion. Neuraxial anesthesia was attempted in 93% of deliveries. The dose chosen for initiation of neuraxial anesthesia was lower than the typical doses used in parturients of normal stature. Neuraxial anesthetic complications included difficult neuraxial placement (64%), high spinal (7%), inadequate surgical level (13%), and unrecognized intrathecal catheter (7%).

Conclusions The data collected suggest that females with a diagnosis of dwarfism may have difficult neuraxial placement and potentially require lower dosages of local anesthetic for both spinal and epidural anesthesia to achieve adequate surgical blockade.

Résumé

Objectif La littérature portant sur la prise en charge anesthésique de parturientes atteintes de nanisme est peu abondante et se limite à des présentations de cas isolées. Parmi les complications de grossesse associées au nanisme, citons un risque accru d'insuffisance respiratoire, un risque accru d'accouchement par césarienne, et un degré imprévisible du niveau d'anesthésie lors du recours à des techniques neuraxiales. Nous avons donc réalisé ce compte rendu rétrospectif afin d'examiner la prise en charge anesthésique des parturientes ayant un diagnostic de nanisme.

Méthode Nous avons utilisé une requête de données de facturation afin d'identifier les femmes de petite taille ayant accouché par césarienne entre le 1^{er} mai 2008 et le 1^{er} mai 2013. Nous avons ensuite recherché manuellement

Paper presentation information: The poster was presented at the 46th annual meeting, Society for Obstetric Anesthesia and Perinatology, Toronto, Ontario, Canada, May 2014 and the American Society of Anesthesiologists Annual Meeting in New Orleans, Louisiana, October 2014.

E. M. S. Lange, MD (✉) · P. Toledo, MD, MPH
Department of Anesthesiology, Northwestern University
Feinberg School of Medicine, 251 E. Huron St. F5-704, Chicago,
IL 60611, USA
e-mail: elizabeth.lange@northwestern.edu

P. Toledo, MD, MPH
Center for Healthcare Studies, Northwestern University Feinberg
School of Medicine, Chicago, IL, USA

J. Stariha, BA · H. C. Nixon, MD
Department of Anesthesiology, University of Illinois Chicago,
Chicago, IL, USA

le dossier médical électronique des patientes se qualifiant avec une taille < 148 cm et un diagnostic de nanisme. Les données extraites des dossiers comprenaient les renseignements démographiques concernant les patientes ainsi que les informations obstétricales et anesthésiques.

Résultats Nous avons identifié 13 femmes atteintes de nanisme pour 15 accouchements par césarienne au total. Douze de ces femmes étaient atteintes d'un nanisme disproportionné et dix des 15 accouchements par césarienne étaient dus à une disproportion céphalo-pelvienne. L'anesthésie neuraxiale a été tentée pour 93 % des accouchements. La dose choisie pour l'amorce de l'anesthésie neuraxiale était plus faible que les doses traditionnellement utilisées chez des parturientes de taille normale. Parmi les complications de l'anesthésie neuraxiale, on a constaté une technique neuraxiale difficile (64 %), une rachianesthésie haute (7 %), un niveau chirurgical inadéquat (13 %), et un cathéter intrathécal non identifié (7 %).

Conclusion Les données recueillies laissent penser que, chez les femmes avec un diagnostic de nanisme, il pourrait être difficile de positionner une anesthésie neuraxiale et que ces patientes pourraient potentiellement nécessiter des doses plus faibles d'anesthésique local tant pour l'anesthésie rachidienne que pour la péridurale pour obtenir un bloc chirurgical adéquat.

Dwarfism is defined as an adult height of 148 cm or less.¹ It has multiple etiologies, including genetic, metabolic, and constitutional predisposition to short stature.¹ While there are many different etiologies of dwarfism, none of them are very common.^{1,2} Although women with some types of dwarfism are unable to conceive and bear children, advances in reproductive technologies have increased the occurrence of parturients with dwarfism in the labour and delivery suite.^{3,4}

As dwarfism is heterogeneous with over 100 different classifications, it is difficult to make generalizations concerning anesthetic management of these parturients.² There are two major classifications of dwarfism—i.e., persons with either proportionate or disproportionate anatomy.² Dwarfism with proportionate anatomy is characterized by a normal trunk to limb ratio, and diagnosis is seen in patients with endocrine pathology, such as isolated growth hormone deficiency, chronic disease, and constitutional predisposition to short stature.^{5,6} Dwarfism with disproportionate anatomy is characterized by an abnormal trunk to limb ratio—i.e., the trunk is either short or long in relation to the limbs.² Achondroplasia is a form of dwarfism characterized by short stature with disproportionate growth.

Parturients with either proportionate or disproportionate dwarfism have an increased risk of Cesarean delivery compared with parturients without a diagnosis of dwarfism. Obstetric management of patients with proportionate dwarfism often necessitates surgical delivery due to cephalopelvic disproportion as well as cardiopulmonary compromise secondary to the impingement of a gravid uterus.⁷ Cesarean delivery is more common in parturients with disproportionate dwarfism as their small pelvis often leads to malpresentation of the fetus or inadequate capacity to accommodate safe delivery of the fetus, which is often normal in size.¹

The short stature of this population can pose many anesthetic challenges, such as a difficult airway, cervical spine instability, and unpredictable analgesic and anesthetic levels with neuraxial blockade.^{2,8–10} Neuraxial blockade may be more technically challenging if spinal stenosis, lumbar hyperlordosis, and thoracolumbar kyphosis are present.^{8,11–15} Due to the large anatomical variation and heterogeneity of dwarfism, there are few guidelines regarding the anesthetic management of the parturient with dwarfism, and most reports in the literature are limited to isolated case reports of anesthetic management in a patient with a particular type of dwarfism. Historically, general anesthesia was the recommended and prudent anesthetic choice for Cesarean delivery in the parturient with dwarfism due to the unpredictable nature of neuraxial anesthesia.^{7,14} We report the anesthetic management of a retrospective series of 13 parturients with a diagnosis of dwarfism who underwent 15 deliveries in total via Cesarean delivery.

Methods

The University of Illinois Hospital and Health Sciences System Internal Review Board approved this historical cohort study and waived the need for patient consent. We used anesthesia billing data to identify all parturients who underwent Cesarean delivery during May 2008 to May 2013. To meet inclusion criteria in our historical cohort study, we hand searched each medical record for both a patient height ≤ 148 cm and a diagnosis of dwarfism. Obstetric, demographic, and anesthetic data were extracted using a standardized form.

Results

Obstetric and demographic data are summarized in Table 1; neuraxial management is summarized in Table 2, and airway management is described in Table 3.

Table 1 Patient demographics, obstetric history, and fetal weight

Pt	Diagnosis	G/P	EGA weeks	Ht (cm)	BMI (kg·m ⁻²)	MPS	Fetal Weight (g)	Indication for Cesarean Delivery
1	Achondroplasia	G3/P2	39.1	127	39	2	3,134	Repeat Cesarean
2	Achondroplasia	G4/P1	37.0	135	35	2	NR	Cephalopelvic disproportion
3	Russell-Silver syndrome	G1/P0	36.1	142	15	2	NR	NRFHT
4	Congenital hypothyroid	G13/P7	35.0	140	41	2	3,370	NRFHT, abruption
5	Congenital hypothyroid	G3/P2	39.0	135	51	2	NR	Repeat Cesarean
6	Achondroplasia	G1/P0	30.6	119	56	2	1,570	Cephalopelvic disproportion
7	Achondroplasia	G2/P1	38.6	122	33	1	NR	Cephalopelvic disproportion
8	Achondroplasia	G1/P0	38.3	114	33	1	2,506	Cephalopelvic disproportion
9	Achondroplasia	G3/P2	38.3	122	37	1	NR	Cephalopelvic disproportion
10	Congenital dwarfism	G1/P0	31.5	119	40	2	1,667	Cephalopelvic disproportion, NRFHT, chronic abruption
11	Rickets	G2/P0	40.3	140	55	2	3,311	Arrest of dilation, chorioamnionitis
12A	Metatropic dysplasia	G1/P0	39.1	122	37	3	3,255	Cephalopelvic disproportion
12B	Metatropic dysplasia	G2/P1	38.5	121	40	3	3,588	Cephalopelvic disproportion
13A	Achondroplasia	G1/P0	39	119	48	1	2,866	Cephalopelvic disproportion
13B	Achondroplasia	G2/P1	39	122	49	1	NR	Cephalopelvic disproportion

BMI = body mass index; EGA = estimated gestational age; G/P = gravity/parity; Ht = height; MPS = Mallampati score; NR = not recorded; NRFHT = non-reassuring fetal heart tones; Pt = patient

Two parturients delivered more than once during the study period (Patient 12A and 12B, and Patient 13A and 13B).

Our study population included patients with proportionate and disproportion short stature. Patient 3 was the only parturient whose diagnosis was classified as proportionate dwarfism. The remaining patients were parturients with disproportionate dwarfism with varied etiologies, including osteochondrodysplasia such as achondroplasia (Patients 1, 2, 6, 7, 8, 9, and 13), metatropic dysplasia (Patient 12), and congenital dwarfism (Patient 10). Patients with congenital hypothyroidism (Patients 4 and 5) and rickets disease (Patient 11) were also considered to have disproportionate dwarfism.

Patients' heights ranged from 119–142 cm. While one patient was underweight, Patient 3 had a body mass index of 15 kg·m⁻², the remaining patients were obese. Two patients were World Health Organization class I for obesity, six were class II, and six were class III.

Seven of 15 deliveries occurred in nulliparous parturients, while the remaining eight deliveries were in multiparous parturients. Ten of the 15 Cesarean deliveries were due to cephalopelvic disproportion documented in the obstetric record. One patient (Patient 3) underwent emergency Cesarean delivery due to non-reassuring fetal status on presentation to the triage unit. Two patients attempted vaginal delivery and subsequently required Cesarean delivery. One (Patient 4) delivered by Cesarean

delivery due to non-reassuring fetal heart as a result of placental abruption. The other (Patient 11) had an operative delivery secondary to arrest of dilation in the setting of chorioamnionitis.

Neuraxial anesthesia was attempted for all deliveries except Patient 3 who required general anesthesia for fetal indications. Labouring women had epidural catheters *in situ* prior to Cesarean delivery. Surgical anesthesia was initiated using a combined spinal-epidural technique in four patients, spinal anesthesia in two patients, and epidural anesthesia in six patients. The drugs and doses used are shown in Table 2.

Complications were varied. Difficulty with neuraxial placement occurred in nine parturients; six required multiple attempts, and in three of the nine, cerebrospinal fluid (CSF) could not be withdrawn during attempted combined spinal-epidural (CSE) anesthesia. Two parturients required conversion to general anesthesia due to inadequate neuraxial blockade (Patients 6 and 11). One patient (Patient 2) had a high spinal blockade necessitating general anesthesia, and another patient (Patient 9) likely had an unrecognized intrathecal catheter.

Four of the deliveries required tracheal intubation, three of which were under emergency conditions. The indications for general anesthesia included high spinal anesthesia with respiratory compromise requiring intubation (Patient 2), non-reassuring fetal status with inadequate time to establish neuraxial anesthesia (Patient

Table 2 Neuraxial anesthetic management

Pt	Anesthesia Consult	Prior anesthetic for previous deliveries	Urgency	Intended Anesthetic	TD	Local anesthetic given to obtain anesthesia	Neuraxial adjuvant	Epidural morphine	Level	Complications
1	None	2 prior Cesareans under spinal	Scheduled	CSE	Lidocaine 1.5% with epi (45mg)	Lidocaine 2% with 1:200K epi (200 mg)	None	1 mg	Adequate	Spinal dose of CSE aborted due to paresthesia
2	Yes	Prior Cesarean under neuraxial	Scheduled	CSE	Lidocaine 1.5% with epi (45mg)	Lidocaine 2% with 1:200K epi (60 mg)	None	None	High spinal	Difficult placement with multiple attempts at epidural and spinal; after dosing, pt became unresponsive desaturated convert to GA
3	None	NA	Emergent	GA	NA	NA	None	NA	NA	None
4	None	4 prior deliveries with epidurals	Emergent	Labour epidural	Lidocaine 1.5% with epi (45mg)	Lidocaine 2% with 1:200K epi (400 mg)	None	4 mg	Adequate	None
5	None	2 prior Cesareans under neuraxial	Scheduled	Epidural	Lidocaine 1.5% with epi (45mg)	Lidocaine 2% with 1:200K epi (260 mg)	None	2 mg	T6	Difficult placement
6	Yes	NA	Scheduled	Epidural	Lidocaine 1.5% with epi (45mg)	Lidocaine 2% with 1:200K epi (260 mg)	None	None	Inadequate	Converted to GA as unable to obtain adequate anesthetic blockade
7	Yes	Prior Cesarean under spinal	Scheduled	Spinal	NA	Hyperbaric bupivacaine 0.75% (8.25 mg)	Morphine 100 µg, fentanyl 25 µg	NA	T3	Difficult placement of neuraxial, multiple attempts
8	Yes	NA	Scheduled	Epidural	None	Lidocaine 2% with 1:200K epi (360 mg)	None	1 mg	T4	None
9	Yes	2 Cesareans under GA (primary failed attempted spinal block)	Scheduled	CSE	Lidocaine 1.5% with epi (45mg)	Bupivacaine 0.25% (0.625 mg)	None	100 µg *	Adequate	While initially TD negative concern for possible IT catheter, difficulty passing spinal needle and unable to obtain CSF
10	Yes	NA	Scheduled	Epidural	Lidocaine 1.5% with epi (45 mg)	Lidocaine 2% with 1:200K epi (40 mg)	None	2 mg	T6	Difficult neuraxial placement requiring multiple attempts
11	None	NA	Emergent	Labour epidural	Lidocaine 1.5% with epi (45mg)	Lidocaine 2% with 1:200K epi (400 mg)/ chloroprocaine 3% (300 mg)	None	3 mg	T4	Pt with bilateral T10 level after test dose, despite T4 level bilaterally T11/12 spared, converted to GA
12A	Yes	NA	Scheduled	Spinal	NA	Hyperbaric bupivacaine 0.75% (7.5 mg)	Morphine, fentanyl 25 µg	4 mg	Adequate	None

Table 2 continued

Pt	Anesthesia Consult	Prior anesthetic for previous deliveries	Urgency	Intended Anesthetic	TD	Local anesthetic given to obtain anesthesia	Neuraxial adjuvant	Epidural morphine	Level	Complications
12B	Yes	Prior Cesarean under neuraxial	Scheduled	Epidural	Lidocaine 1.5% with epi (45mg)	Lidocaine 2% with 1:200K epi (140 mg)	None	None	T3	Difficult placement requiring multiple attempts and paramedian approach
13A	Yes	NA	Scheduled	CSE	NA	Hyperbaric bupivacaine 0.75% (6.75 mg)	Fentanyl 25 µg	None	Adequate	None
13B	Yes	Prior Cesarean under CSE	Scheduled	Epidural	Lidocaine 1.5% with epi (45 mg)	Lidocaine 2% with 1:200K epi (120 mg)	None	None	Adequate	None

CSE = combined spinal-epidural; CSF = cerebral spinal fluid; epi = epinephrine; GA = general anesthesia; IT = intrathecal; NA = not applicable; Pt = patient; TD = test dose. *Concern that catheter was intrathecal; therefore, morphine was dosed accordingly

3), and failed neuraxial anesthesia (Patients 6 and 11). All intubations required only one attempt at laryngoscopy. Size 6.0-6.5 mm endotracheal tubes were used.

Discussion

Due to the heterogeneity of dwarfism, it is difficult to make generalizations concerning anesthetic management for delivery as the majority of reports in the literature are limited to individual case reports.^{8-10,12,14,16-20} Our study provides an evaluation of 15 deliveries in 13 parturients with a diagnosis of dwarfism and their anesthetic management for Cesarean delivery. This review better characterizes the responses to different anesthetic techniques in this patient population than provided by single case reports in previous publications.

Many parturients with a diagnosis of dwarfism must undergo Cesarean delivery due to cephalopelvic disproportion.^{2,7} The majority of the patients in our historical cohort were diagnosed with achondroplastic dwarfism. Their disproportionate short stature may increase the risk of cephalopelvic disproportion, particularly if the neonate is of normal stature.^{2,21} It is important to bear in mind that a subset of patients with dwarfism may indeed be able to deliver vaginally. Our data do not represent these patients as we identified our patients from Cesarean delivery anesthetic records.⁷ The indication for Cesarean delivery in three of the parturients with failed labour was unrelated to cephalopelvic disproportion.

A neuraxial technique was attempted in almost all patients. Anesthetic dosing for neuraxial procedures may be of concern in patients with abnormal stature, as the high blockade could be catastrophic in patients with a difficult airway. The anatomical differences among dwarfism patients may account for the variation in drug dosage required to obtain adequate neuraxial anesthesia for Cesarean delivery.^{9,10} Successful CSE, epidural, and spinal anesthesia were achieved in our study population, yet the doses used were generally lower than those used in parturients of normal stature.²²⁻²⁴ Given that adequate anesthesia was achieved in some patients with intrathecal bupivacaine 6.75-8.25 mg and epidural lidocaine 40-60 mg, it may be prudent to initiate anesthesia using a low-dose spinal as part of a combined spinal-epidural technique or to titrate epidural anesthesia slowly in order to avoid inadequate anesthesia or high blockade with single-shot spinal anesthesia.

The complications of neuraxial anesthesia in our series are similar to those cited in the literature. The difficulty with neuraxial analgesia placement is likely due to spinal distortion, increased incidence of scoliosis, thoracolumbar kyphosis, and lumbar hyperlordosis.^{9,10,15} The majority of

Table 3 Airway management

Pt	Induction	Direct Laryngoscopy Attempts	Blade	View	Tube Size
2	Rapid sequence	1	MAC 3	1	6.0 mm
3	Rapid sequence	1	MAC 4	Not Recorded	6.5 mm
6	Rapid sequence	1	MAC 3	1	6.0 mm
11	Rapid sequence	1	C-MAC 4	1	6.5 mm

Pt = patient

the patients in our study had difficult neuraxial placements requiring multiple attempts and an inability to obtain CSF during attempted CSE anesthesia. Moreover, the repeated attempts at neuraxial anesthesia may lead to unrecognized dural punctures. This may lead to unintentional intrathecal catheter placement and translocation of local anesthetic, which may result in an unexpectedly high blockade. In our series, one patient required emergency tracheal intubation as a result of a high spinal blockade. Another patient required extremely low doses of local anesthetic via her catheter to maintain adequate anesthesia, suggesting that, despite a negative test dose, her catheter was indeed intrathecal.

The skilled anesthesiologist may be concerned about difficulty with both mask ventilation and intubation due to the characteristic airway features associated with dwarfism, and there are numerous case reports to support this concern.^{25,26} We cannot comment on the difficulty of mask ventilation, as all intubations were performed via rapid sequence induction given the increased risk of aspiration in the parturient with dwarfism.⁷ Though only few patients required tracheal intubation, our findings are consistent with those of Mayhew *et al.* who examined the airway and intubation of 36 dwarfism patients and reported no difficulty in airway management.²⁷ Similarly, Monedero *et al.* reviewed 53 general anesthetics in patients with mostly achondroplastic dwarfism and they found no airway complications.²⁸ Although we encountered no problems in securing the airway, our sample size is small; therefore, we cannot make generalizations about the safety of tracheal intubation in parturients with dwarfism. Given the anatomic abnormalities associated with dwarfism, the potential for difficult intubation exists; therefore, the anesthesia provider should be prepared with advanced airway equipment if concerns arise on physical examination to suggest a difficult airway.

There are limitations to our historical cohort study. We chose to concentrate on the anesthetic management of parturients with dwarfism requiring Cesarean delivery as many such parturients require Cesarean delivery^{1,7} due to anatomic considerations that increase the risk for airway complications^{2,8–10} and other anesthetic morbidities.^{8,11–15} Furthermore, we used anesthesia billing data, and since

these billing records do not capture all labouring women, we were able to capture only those dwarfism parturients who had vaginal delivery with neuraxial labour analgesia. Therefore, our population consisted primarily of parturients with disproportionate dwarfism who might have different anesthetic requirements than parturients with proportional dwarfism. Achondroplastic dwarfism was the most prominent type of dwarfism in our study. This is consistent with the general population, as achondroplastic dwarfism is the most common type of dwarfism, occurring in 0.5–1.5 per 10,000 live births.^{2,21} The data presented in this study are retrospective, but given the rarity of this condition in the labour and delivery suite, prospective assessment may be difficult. Furthermore, while many of the parturients experienced difficulty with their anesthetics, data were not available to determine whether this affected their satisfaction.

In conclusion, our cohort highlights many of the challenges and complications associated with the anesthetic management of parturients with dwarfism. Considering that these potential difficulties may result in challenges in the delivery suite, we encourage preanesthetic counselling, including a complete history and physical examination. The focus of the examination should be on the patient's airway, cardiac and pulmonary assessments, as well as an examination of the patient's back to assess for scoliosis, thoracolumbar kyphosis, and lumbar hyperlordosis. As with patients with a history of back surgery, proper informed consent regarding neuraxial procedures in the setting of dwarfism should be thoroughly discussed with the patient. This discussion should include the possibility of prolonged placement time, a technically challenging procedure, risk of inadequate neuraxial anesthesia, unilateral blockade, unintentional dural puncture, intrathecal catheter, and total spinal blockade.²⁹ The use of ultrasound was not documented in any of our patients' records, and it is unlikely that ultrasound was used given the timing of the study during a period when ultrasound was not frequently used for neuraxial placement on our labour and delivery ward. Nevertheless, the use of ultrasound guidance for neuraxial procedures may be advisable in this patient population. In addition, patients should be prepared for potential awake fibreoptic

intubation should concerns arise from their airway examination regarding difficult ventilation and intubation.

Acknowledgement We sincerely thank Dr. Cynthia Wong for help in reviewing the manuscript.

Financial support Funding for this study was provided by the University of Illinois Chicago, Department of Anesthesiology. Paloma Toledo, MD MPH was supported by a grant from a Robert Wood Johnson Foundation program—i.e., the Harold Amos Medical Faculty Development Program (award 69779). The content is solely the responsibility of the authors and does not necessarily represent the official views of the Robert Wood Johnson Foundation.

Conflicts of interest None declared.

Author contributions Elizabeth M. S. Lange and Heather C. Nixon contributed to study conception. Elizabeth M. S. Lange, Heather C. Nixon, and Paloma Toledo contributed to the study design and interpretation of data. Elizabeth M. S. Lange contributed to data acquisition and drafted the manuscript. Paloma Toledo assisted with manuscript preparation. Paloma Toledo and Heather C. Nixon aided in manuscript revision. Jillian Stariha was responsible for the acquisition of data and for revising the manuscript.

Editorial responsibility This submission was handled by Dr. Philip M. Jones, Associate Editor, *Canadian Journal of Anesthesia*.

References

1. Tyson JE, Barnes AC, McKusick VA, Scott CI, Jones GS. Obstetric and gynecologic considerations of dwarfism. *Am J Obstet Gynecol* 1970; 108: 688-704.
2. Berkowitz ID, Raja SN, Bender KS, Kopits SE. Dwarfs: pathophysiology and anesthetic implications. *Anesthesiology* 1990; 73: 739-59.
3. de Boer HD, Hemelaar A, van Dongen R, Gielen MJ. Successful epidural anaesthesia for caesarean section in a patient with spondyloepiphyseal dysplasia. *Br J Anaesth* 2001; 86: 133-4.
4. Vogel TM, Ratner EF, Thomas RC Jr, Chitkara U. Pregnancy complicated by severe osteogenesis imperfecta: a report of two cases. *Anesth Analg* 2002; 94: 1315-7.
5. Mazzanti L, Tamburrino F, Bergamaschi R, et al. Developmental syndromes: growth hormone deficiency and treatment. *Endocr Dev* 2009; 14: 114-34.
6. Wit JM, Oostdijk W, Losekoot M. Spectrum of insulin-like growth factor deficiency. *Endocr Dev* 2012; 23: 30-41.
7. Allanson JE, Hall JG. Obstetric and gynecologic problems in women with chondrodystrophies. *Obstet Gynecol* 1986; 67: 74-8.
8. Beilin Y, Leibowitz AB. Anesthesia for an achondroplastic dwarf presenting for urgent cesarean section. *Int J Obstet Anesth* 1993; 2: 96-7.
9. DeRenzo JS, Vallejo MC, Ramanathan S. Failed regional anesthesia with reduced spinal bupivacaine dosage in a parturient with achondroplasia presenting for urgent cesarean section. *Int J Obstet Anesth* 2005; 14: 175-8.
10. Palomero MA, Vargas MC, Pelaez EM, Rodriguez-Ceron A, Sanchez-Conde P, Muriel C. Spinal anaesthesia for emergency caesarean section in an achondroplastic patient. *Eur J Anaesthesiol* 2007; 24: 981-2.
11. Cohen SE. Anesthesia for cesarean section in achondroplastic dwarfs. *Anesthesiology* 1980; 52: 264-6.
12. Brimacombe JR, Caunt JA. Anaesthesia in a gravid achondroplastic dwarf. *Anaesthesia* 1990; 45: 132-4.
13. Morrow MJ, Black IH. Epidural anaesthesia for caesarean section in an achondroplastic dwarf. *Br J Anaesth* 1998; 81: 619-21.
14. Walts LF, Finerman G, Wyatt GM. Anaesthesia for dwarfs and other patients of pathologic small stature. *Can Anaesth Soc J* 1975; 22: 703-9.
15. Porter M, Mendonca C. Anaesthesia for caesarean section in a patient with diastrophic dwarfism. *Int J Obstet Anesth* 2007; 16: 145-8.
16. Crawford M, Dutton DA. Spinal anaesthesia for caesarean section in an achondroplastic dwarf. *Anaesthesia* 1992; 47: 1007.
17. McGlothlen S. Anesthesia for cesarean section for achondroplastic dwarf: a case report. *AANA J* 2000; 68: 305-7.
18. Ravenscroft A, Govender T, Rout C. Spinal anaesthesia for emergency caesarean section in an achondroplastic dwarf. *Anaesthesia* 1998; 53: 1236-7.
19. Ravenscroft A, Rout C. Epidural anaesthesia for caesarean section in an achondroplastic dwarf. *Br J Anaesth* 1999; 82: 301-3.
20. Wardall GJ, Frame WT. Extradural anaesthesia for caesarean section in achondroplasia. *Br J Anaesth* 1990; 64: 367-70.
21. Orioli IM, Castilla EE, Barbosa-Neto JG. The birth prevalence rates for the skeletal dysplasias. *J Med Genet* 1986; 23: 328-32.
22. Carvalho B, Durbin M, Drover DR, Cohen SE, Ginosar Y, Riley ET. The ED50 and ED95 of intrathecal isobaric bupivacaine with opioids for cesarean delivery. *Anesthesiology* 2005; 103: 606-12.
23. Bryson GL, Macneil R, Jeyaraj LM, Rosaeg OP. Small dose spinal bupivacaine for cesarean delivery does not reduce hypotension but accelerates motor recovery. *Can J Anesth* 2007; 54: 531-7.
24. Norris MC. Height, weight, and the spread of subarachnoid hyperbaric bupivacaine in the term parturient. *Anesth Analg* 1988; 67: 555-8.
25. Van Hecke D, De Ville A, Van der Linden P, Faraoni D. Anaesthesia and orphan disease: a 26-year-old patient with achondroplasia. *Eur J Anaesthesiol* 2013; 30: 776-9.
26. Mather JS. Impossible direct laryngoscopy in achondroplasia. A case report. *Anaesthesia* 1966; 21: 244-8.
27. Mayhew JF, Katz J, Miner M, Leiman BC, Hall ID. Anaesthesia for the achondroplastic dwarf. *Can Anaesth Soc J* 1986; 33: 216-21.
28. Monedero P, Garcia-Pedrajas F, Coca I, Fernandez-Liesa JJ, Panadero A, de los Rios J. Is management of anesthesia in achondroplastic dwarfs really a challenge? *J Clin Anesth* 1997; 9: 208-12.
29. Bauchat JR, McCarthy RJ, Koski TR, Wong CA. Labor analgesia consumption and time to neuraxial catheter placement in women with a history of surgical correction for scoliosis: a case-matched study. *Anesth Analg* 2015; 121: 981-7.