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REVIEW ARTICLE - SPINE

Lumbar disk herniation during pregnancy: a review on general management and timing of surgery

Hugo Ardaillon[1] · **Yosef Laviv**[2] · **Jeffrey E. Arle**[2] · **Ekkehard M. Kasper**[2]

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Abstract
Study design Narrative review with case illustration.
Objective Provide an overview of existing management strategies to suggest a guideline for surgical management of lumbar disk herniation in pregnant women based on time of presentation.
Methods We performed a narrative review on the topic using the PubMed database. A total of 63 relevant articles published after 1992 were identified, of which 17 fulfilled selection criteria.
Results A total of 22 published cases of spine surgery for disk herniation during pregnancy were found in 17 studies on the topic. Prone positioning was reported in the majority of cases during the first and early second trimester. C-sections were performed prior to spine surgery in the prone position for the majority of patients operated during the third trimester. The left lateral position with continued pregnancy was preferred during the latter half of the second trimester when delivery of the fetus cannot yet be performed but surgery is indicated.
Conclusion Spine surgery during pregnancy is a rare scenario but can be performed safely when needed if providers adhere to general guidelines. Surgical approaches and overall management are influenced by the stage of pregnancy.

✉ Ekkehard M. Kasper
ekasper@BIDMC.harvard.edu

Hugo Ardaillon
hugo.ardaillon@etu.univ-lyon1.fr

[1] Lyon-Sud School of Medicine, University Claude-Bernard Lyon-1, Chemin du Grand Revoyet, 69310 Pierre-Bénite, France

[2] Department of Neurosurgery, Beth Israel Deaconess Medical Center, One Deaconess Road, Boston, MA 02215, USA

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Introduction

Non-obstetric surgery in parturient patients has been described with a frequency of about 1–2% for a number of different conditions [16]. To the best of our knowledge and based on available data across various subspecialties, this can be performed without significantly increased risk to the developing fetus [14]. Reported surgical mortality is not significantly increased in pregnant women compared to non-pregnant women of the same age [15], but these patients require a more comprehensive management by a multidisciplinary team composed of physicians from fetal-maternal medicine, obstetrics, subspecialty surgery and anesthesiology. The main issue when operating on pregnant women is that one has to simultaneously take care of two patients instead of only one: the developing child and the mother. Each decision to intervene must therefore be balanced with the risk and benefits for both the fetus and the mother.

Back pain and lumbalgia (low back pain; LBP) are very common during pregnancy, affecting about one in two women [45]. However, LBP is very rarely associated with true radiculopathy from disc herniation, a condition that has been estimated to affect approximately 1 in 10,000 pregnant women [33]. Leban et al. reported that over a period of 10 years, only 5 patients out of an observational cohort of 48,760 parturients were identified to display clear clinical signs of lumbar disc herniation, which was later confirmed by imaging via myelography [33]. Adjusted for the population of the entire USA, this translates to about 400 women per year in the US suffering from this condition [27]. Based on available

published reports on lumbar disk disease, one expects that fewer than 15% of lumbar disc herniations lead to severe neurologic deficits [19], cauda equina syndrome (CES) being the most feared. Only a small number of these women will need surgical intervention since conservative non-surgical management remains the initial treatment of choice and has proven to be highly effective, except in cases of CES. Consequently, the actual number of spine surgeries performed for symptomatic disc herniation occurring during pregnancy is very low, and encountering such a case is a rare problem for which most practitioners are not well prepared. With this study, we want to help to demystify the issue.

After failed non-surgical management of significant LBP or in the rare setting of clear signs of severe unilateral or bilateral radiculopathy or with actively evolving CES at onset, a surgical approach must be considered for pregnant women presenting with neurologic deficits or intolerable pain, because neurologic deficits can lead to irreversible sequelae [25]. It is hence essential for physicians to be aware of the fact that certain urgent or even emergent situations during pregnancy have to be diagnosed expeditiously and be treated as soon as reasonably possible, regardless the stage of the pregnancy, because misdiagnosis or delayed treatment (e.g., of incomplete CES without bladder and bowel dysfunction) may lead to permanent neurologic sequelae.

Performing spine surgery in parturients is a challenge for all involved physicians and needs to be planned well to ensure best possible outcomes at minimum risk for both mother and child.

Since spine surgery for herniated lumbar disk in pregnant woman is an unforeseen complicated scenario and rare, there are no level I or II data available on the topic, and most of the published literature consists of case reports only. However, we hoped to gain further insight into this problem by performing a pooled analysis of all such reports from the current literature. To this end we present a narrative review of the literature up to September 2016 to obtain clinical practice guidelines for spine surgery (discectomy) for lumbar disk herniation during pregnancy.

Beyond that, and to illustrate this problem from a practical perspective, we use one such case from our institution for illustration: Here, a 39-year-old female was admitted for severe radicular pain in the setting of a L5-S1 lumbar disc herniation discovered in her second trimester. This case will be put into the appropriate context, which will allow us to discuss the management of such presentations during each trimester.

Methods

We performed a narrative review of the literature.

Data collection process

A literature search using the PubMed database was conducted for any reports published after 1992 and up to 1 September 2016 in combination with a thorough hand search. Search terms used were: “pregnant” or “pregnancy” or “parturient” and “disc hernia” or “disc herniation” or “herniated disc.” These terms were combined using the algorithmic terms “AND” and “OR” to retrieve pertinent study titles of reports and abstracts: (((pregnant) OR pregnancy) OR parturient) AND (((disc herniation) OR disc hernia) OR herniated disc).

The following filters were used: abstract available, humans, English language, adults and academic journals. We only searched and retrieved articles published after 1 January 1992 with the intention to include all reports that were made available in the MRI era. Publications had to include a neurologic status of the patient before intervention, an assessment of the pregnancy, MR imaging data as well as outcome for both the mother and the child.

Eligibility criteria

Our inclusion criteria allowed to identify and select English language studies, outcomes studies, studies on adult pregnant women, case reports and reviews, with abstract and full text available. Exclusion criteria included: non-English language studies and articles prior to 1992 (when MRI was not yet routinely used). We selected only cases for which symptoms occurred during pregnancy. We studied both surgery during pregnancy and delivery, but also accepted cases in which surgery was done less than 1 week post-partum, but not if surgery was performed more than 1 week after delivery. Duplicates were checked. Ninety-eight articles were initially identified and retrieved, but only 63 of these were on patients treated after 1 January 1992. Forty-four articles were not relevant to our investigation; one article was in a foreign language and will hence only be cited in the discussion [6]. One article [48] reported surgery performed as late as 4 weeks after delivery and was therefore excluded. After applying all pertinent selection criteria, only 17 relevant articles remained.

One article [34] reported six cases of lumbar disc herniation (LDH) during pregnancy, but only one out of their six patients was managed with surgery after failure of conservative management. The five others patients were either successfully managed with conservative treatment or miscarriage occurred before surgery. Therefore, only this one case is included in our analysis and will be reviewed here.

Summary and synthesis

We compiled 22 cases of LDH as extracted from 17 separate search-retrieved articles. The nature of the majority of articles, being single case reports or small case series, prevented us

from performing a thorough quantitative systematic review. Demographics, pre-surgical symptoms, indication for surgery and imaging findings are listed in Table 1. Anesthetic, surgical management and outcomes for mother and fetus are listed in Table 2.

Results

Out of 63 English language studies published after 1 January 1992, only 17 articles met the eligibility criteria, yielding a total of 22 individually reported cases.

The average age of the mother at LDH diagnosis was 32 years and 11 months, and the average age of the respective pregnancy was 24 weeks and 6 days.

Twelve patients presented with some form of cauda equina syndrome and were operated emergently. The other ten patients suffered from low back pain and/or radiculopathy only, and the indication for surgery was either unsuccessful conservative management or a progression of the symptoms.

Thirteen patients suffered from an LDH at L5-S1, whereas nine patients suffered from LDH at L4-L5 with one of them suffering from a two-level LDH at L4-L5 and L5-S1 [23]; only one patient suffered from a LDH at L3-L4 [37].

Among all 22 reviewed cases, only 1 parturient patient underwent surgery during the first trimester [22], 11 in the second trimester [1, 10, 22, 25, 28, 29, 34, 35, 37] and 10 in the third trimester of pregnancy [5, 10, 20, 22–24, 30, 32, 44].

The surgical position for the single case of surgery performed during the first trimester was not specified (1/1), which was also the case for two surgeries during the second trimester (2/11) [22, 34] and one in the third trimester (1/10) [22]. Therefore, we can only assume that if not specified, those patients were operated on in prone position. For consistency of data, we listed this information as "N/A" in Table 2 and Fig. 3.

During the second trimester, three women underwent a surgery in left lateral position (3/11) [28, 29, 35], while 6 others were placed in the regular prone position (6/11) [1, 11, 25, 37].

During the third trimester, five women were managed with a delivery of the baby by cesarean section followed by a discectomy in prone position (5/10) [5, 10, 23, 24, 44]. Only two were positioned in the left lateral position (2/10) [30, 32] and two others in the prone position without prior delivery (2/10) [20].

Case illustration

A 39-year-old G2P1 pregnant woman in her second trimester was admitted to our institution for severe radicular pain in the L5-S1 distribution in the setting of a central and right L5-S1 lumbar disc herniation seen on the MRI scan (Fig. 1). The pain worsened significantly with axial load when standing upright or when trying to walk.

Initial symptoms, which started during the 14th week of gestation, were first treated conservatively and then with a focal epidural steroid injection. Both measures were inefficient in controlling her pain.

Following the patient's wishes, it was first decided to postpone surgery as long as possible with the aim to get the pregnancy further advanced to the second trimester or ideally to wait until after delivery. However, due to the resistance of symptoms to any conservative approach and intense and intractable pain affecting the patient's daily activities, a plan for surgery was made after a multidisciplinary meeting.

The patient underwent surgery in her 17th week of gestation, approximately 3 weeks after the onset of her symptoms. Given the small size of her gravid uterus at this early stage of pregnancy, surgery was performed under general anesthesia in prone position with appropriate chest and hip bolsters, and the fetus was monitored before and after the surgery. A right L5 hemi-laminectomy and microdiscectomy were performed, and surgery went well without any immediate sequela. Unfortunately, a wound dehiscence with *Staphylococcus aureus* infection occurred on postoperative day 14, which required surgical wound washout. Again, a prone position with perioperative fetal monitoring was used. The patient had a complete recovery, with complete resolution of her pre-surgical symptoms. Pregnancy was continued to term and the patient delivered a healthy infant.

Discussion

Low back pain is a common symptom during pregnancy, with an astonishingly high incidence of 54%–76% [45]. The reasons for lumbalgia are manifold and may even be considered due to expected physiologic changes such as uterus expansion, increased lumbar lordosis, hormonal changes and weight gain leading to altered compliance and increased mechanical stress on the spine. However, the fact that most developed countries are also witnessing an ever-increasing number of late-age parturients adds to the aspect of preexisting degenerative disease to the already complex picture.

The implication of possible mechanical factors as the main culprit must be examined with caution since many parturients experience low back pain as early as the first trimester, when the uterus is not enlarged yet and cannot account for gravitational pull.

This observation points to other causative factors as determinants for lumbalgia and possible LDH. One physiologic mechanism that comes to mind is the changing milieu of circulating hormones, e.g., the release of pregnancy-augmented hormones such as relaxin during the third trimester, which might soften the ligaments of the spine and pelvis and increase

Table 1 Study details: demographics, symptoms and radiologic findings

	First author (year)	N	Age of the mother (years)	Age of pregnancy during surgery (weeks)	Pre-surgical Symptoms	Indication of surgery	Radiographic findings
1	Hayakawa (2015)	1	38y	24w	LBP left radiculopathy	Resistance to conservative management	LDH L4-5
2	Martel (2015)	1	27y	27w	LBP left radiculopathy	Resistance to conservative management	LDH L3-L4
3	Geftler (2015)	1	33y	36w	LBP CES right radiculopathy	Presence of CES	LDH L4-L5; L5-S1
4	Ochi (2014)	1	33y	34w	LBP left radiculopathy	Resistance to conservative management Progression of symptoms	Left LDH L4-L5 1 day after surgery: right LDH L4-L5
5	Hakan (2012)	1	34y	25w	LBP CES	Presence of CES	LDH L5-S1 S1-S2
6	Lee (2011)	1	32y	21w	LBP Right radiculopathy	Resistance to conservative management Progression of symptoms	LDH L4-5
7	Gupta (2008)	1	37y	35w	LBP CES	Presence of CES	LDH L5-S1
8	Kim (2007)	1	30y	30w	LBP left radiculopathy CES	Presence of CES	LDH L4-L5
9	Al-areibi A (2007)	1	33y	35w	LBP right radiculopathy CES	Presence of CES	LDH L5-S1
10	Kathirgamanathan (2006)	1	34y	33w	LBP left radiculopathy CES	Presence of CES	LDH L4-L5
11	Abou-Shameh (2006)	1	34y	18w	LBP right radiculopathy	Resistance to conservative management	LDH L4-5
12	Brown (2004)	1	35y	34w	LBP bilateral radiculopathy CES	Progression of symptoms Presence of CES	LDH L5-S1
13	Iyilikci (2003)	1	31y	20w	LBP right radiculopathy	Severe compression to right L5 root	LDH L5-S1
14	Brown (2001)	3	41y	20w	LBP bilateral radiculopathy CES	Presence of CES	LDH L5-S1
			31y	20w	LBP right radiculopathy	Resistance to conservative management	LDH L5-S1
			32y	16w	LBP right radiculopathy	Resistance to conservative management	LDH L5-S1
15	Fahy (1998)	2	32y	32w	LBP left radiculopathy CES	Progression of symptoms and development of CES	LDH L4-L5
			31y	33w	LBP left radiculopathy	Resistance to conservative management	LDH L4-L5
16	Garmel (1997)	3	29y	24w	LBP left radiculopathy CES	Resistance to conservative management Progression of symptoms and development of CES	LDH L5-S1
			34y	9w	Left radiculopathy	Resistance to conservative management Progression of symptoms	LDH L5-Sl
			28y	30w	LBP left radiculopathy CES	Resistance to conservative management Progression of symptoms Presence of CES	LDH L5-S1
17	LaBan (1995)	6	36y	20w	LBP CES	Progression of symptoms Presence of CES	LDH L5-S1

LBP, low back pain; CES, cauda equina syndrome; LDH, lumbar disc herniation; L, lumbar; S, sacral

Table 2 Study details: surgical management and outcomes

	First author (year)	N	Age of the mother	Age of pregnancy during surgery	Trimester	Surgical management	Anesthetic management	Outcomes for the mother
1	Hayakawa (2015)	1	38y	24 w	2	LLP	GA	Resolution
2	Martel (2015)	1	27y	27w	2	PP	GA	Resolution
3	Geftler (2015)	1	33y	36w	3	C > PP	GA	Resolution
4	Ochi (2014)	1	33y	34w	3	C > PP	Epidural	18-month follow-up: numbness and mild weakness
5	Hakan (2012)	1	34y	25w	2	PP	GA	Resolution
6	Lee (2011)	1	32y	21w	2	LLP	GA	Resolution
7	Gupta (2008)	1	37y	35 w	3	C > PP	GA	Resolution
8	Kim (2007)	1	30y	30w	3	LLP	N/A	3-month follow-up: hypoesthesia and mild weakness
9	Al-areibi A (2007)	1	33y	35w	3	C > PP	GA	Resolution
10	Kathirgamanathan (2006)	1	34y	33w	3	LLP	GA	Resolution
11	Abou-Shameh (2006)	1	34y	18w	2	PP	GA	Resolution
12	Brown (2004)	1	35y	34w	3	C > PP	GA	12-month follow-up:mild hypoesthesia
13	Iyilikci (2003)	1	31y	20 w	2	LLP	GA	Resolution
14	Brown (2001)	3	41y	20w	2	PP	Epidural	4-year follow-up:persistent hypoesthesia, minimal urinary stress incontinence, constipation
			31y	20w	2	PP	Epidural	15-month follow-up:mild hypoesthesia
			32y	16w	2	PP	Epidural	10-month follow-up: mild weakness
15	Fahy (1998)	2	32y	32w	3	PP	GA	7-month follow-up:residual weakness
			31y	33w	3	PP	GA	Resolution
16	Garmel (1997)	3	29y	24w	2	N/A	N/A	6-week follow-up: mild hypoesthesia
			34y	9w	1	N/A	N/A	Deep venous thrombosis
			28y	30w	3	N/A	N/A	12-week follow-up:mild numbness
17	LaBan (1995)	6	36y	20w	2	N/A	N/A	Resolution

PP, prone position; LLP, left lateral position; C > PP, cesarean section then discectomy in prone position in the same anesthesia; N/A, unknown position

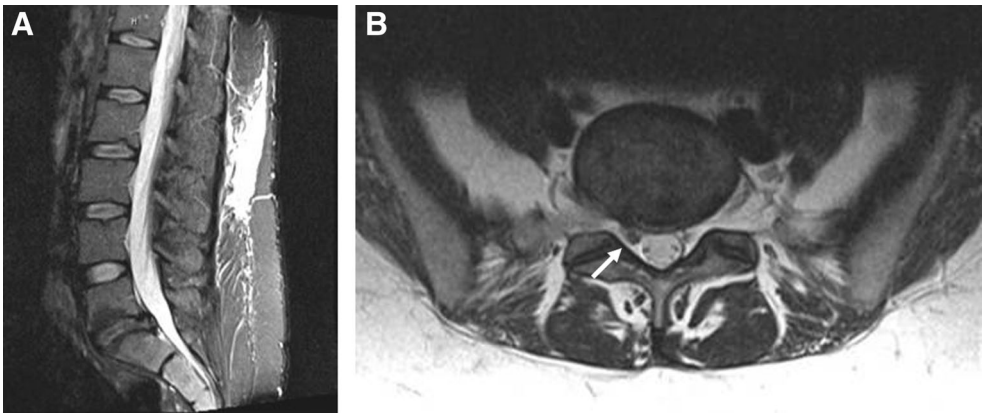

Fig. 1 **a** Sagittal T2-weighted MRI scan of the lower spine, showing L5-S1 lumbar disc herniation. Associated inflammatory changes in the end plates are seen. **b** Cross-sectional T2-weighted MRI scan of level L5-S1 showing a right lumbar disc herniation compressing the nerve root

the incidence of lumbalgia and the risk of lumbar disc herniation during the later stages of pregnancy [36]. All those factors can be implicated and can also exacerbate a pre-existing underlying condition.

The incidence of a single-level herniated disk in pregnancy is not infrequent and presents itself in about 1 in 10,000 patients, usually at the lumbar level [33]. The real number may actually be significantly higher [34], though not all patients seek medical attention or therapy at the time [22]. The symptomatology of herniated disks is varied, ranging from moderate lower back pain only to acute and severe pain with and without neurologic deficits. The first step of good clinical management is to assess and appropriately recognize the gravity of symptoms and to propose a suitable treatment strategy according to the clinical status of the patient.

Surgical treatment is indicated [4] when the patient faces intractable pain and/or a progressive neurologic deficit (motor or sensory) after failed control by non-surgical measures over 6–8 weeks, which can present as radiculopathy or incomplete or complete cauda equina syndrome. However, in cases of LBP alone, conservative treatment should be attempted first [8], which can be a combination of bed rest for a maximum of 3 days, activity modification, a physical therapy program, analgesics, muscle relaxants, spinal manipulation therapy or minimal invasive measures such as TENS or epidural injections [4, 22, 32, 34, 40, 46]. Acetaminophen is the recommended agent of choice in all trimesters because it seems to be the best tolerated drug and has the fewest reported side effects—whereas other nonsteroidal anti-inflammatory agents (NSAIDs) should be avoided in pregnancy because these may confer a higher risk of miscarriage and malformations [17, 18, 41–43]. Over 85% of patients facing such a problem in pregnancy will indeed improve after an average period of 6 weeks without any surgical management needed [19] (Fig. 2).

The American College of Obstetricians and Gynecologists (ACOG) recommends postponing procedures until after delivery or at least until well into the second trimester, although it recognizes that surgery cannot be delayed in some cases [2]. A rapidly progressing neurologic deficit should always be considered a red flag requiring imaging work-up without further delay as it may lead to surgery right away for certain conditions for which care should not be delayed despite an ongoing pregnancy [49].

If surgical intervention is needed, regional anesthesia such as epidural anesthesia should be considered because it results in less drug exposure to the fetus in utero, which translates to

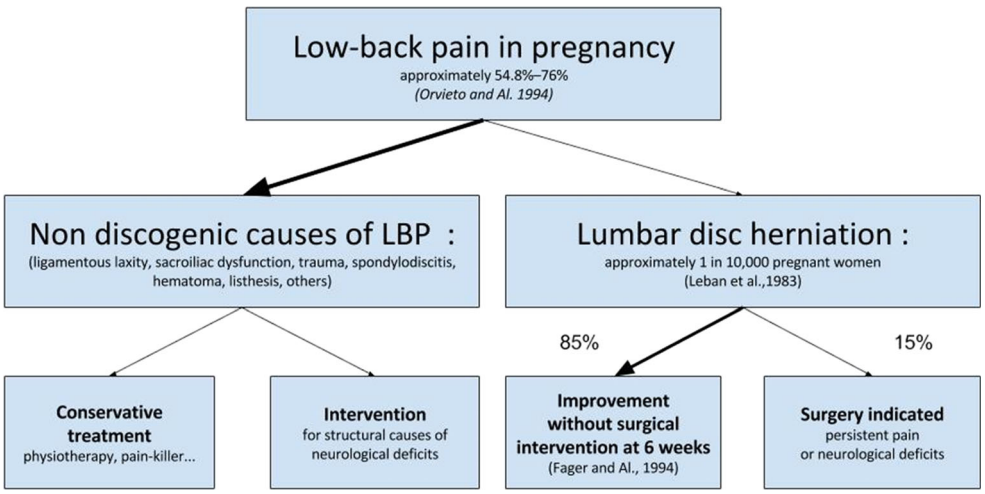

Fig. 2 Clinical presentation of low-back pain and LDH during pregnancy

less variability in the fetal heart rate. This is preferred by fetal maternal medicine over general anesthesia [29, 31]. The general obstetric rules for managing pregnant patients remain unchanged despite the neurosurgic nature of the procedure. The maternal safety should come first, maternal hypoxia, hypocarbia and hypotension should be avoided, and preterm labor prevented [4].

Pregnancy constitutes a complex scenario for healthcare providers to deal with because there are two patients to be considered at the same time: the mother and the developing fetus/child. Certain pathophysiologic responses of a parturient patient in distress will not be the same as those found in a similar condition for a non-parturient patient. Even expected physiologic changes (e.g., in the cardiovascular and renal function) will have an impact on management strategies in surgery and anesthesia [24]. During pregnancy there is an increase in the circulating blood volume, glomerular filtration rate, increased oxygen need with concurrent decreased pulmonary capacity and functional reserve. These changes require anesthetic management to focus on potential episodes of hypoxemia, hypotension, acidosis, hypo- or hyperventilation among other known changes in metabolism and pharmacodynamics. Intraoperatively, this situation demands careful monitoring of respiratory and hemodynamic status for close surveillance and risk avoidance [13]. A baseline blood pressure must be carefully assessed by an arterial line to maintain adequate perfusion pressure, which determines uterine blood flow during surgery [7]. The mother should be monitored for blood pressure and oxygen saturation during surgery, and uterine activity should be monitored with a tocodynamometer [11].

Regarding the monitoring of the fetal heart rate, it has been recommended that once the fetus is more than 25 weeks old, one must monitor the fetal heart rate before, during and after the surgery, together with a presurgical Doppler ultrasound. If a fetal heart rate abnormality is found, the obstetric team would take the appropriate action to safeguard the fetus, such as a cesarean section to deliver the baby emergently [31].

If the fetus is less than 25 weeks, and therefore not yet viable ex utero, there is no need to monitor the fetal heart rate during the procedure [11, 31], because no suitable intervention (such as extraction by cesarean section) is possible, since delivery would lead to the death of the fetus. A fetal heart rate and Doppler ultrasound should be obtained once before the surgery and once after to document the viability of the fetus.

Many complications can occur during surgery. The most feared are infection, nerve root injury, acute bleeding, CSF leak, incomplete resection of the disc material compressing the thecal sac, reoperation, pulmonary embolism and deep vein thrombosis [3]. The risk of having at least one postoperative complication was estimated to be about 5.60% for lumbar discectomy and carries a rate of 2% for reoperations for non-degenerative pathologies such as wound infection, dehiscence or hematomas [12].

Fortunately, a plethora of studies in a number of subspecialties have demonstrated that surgical mortality is not significantly increased in pregnant women compared to non-pregnant women of the same age [14, 15, 39].

Still, parturients admitted to neurosurgery are vulnerable for neurologic sequelae and require well-planned and prudent management by the anesthesiologist [38]. It has therefore been recommended that a multidisciplinary team composed of surgeons, an obstetrician and anesthesiologist should work closely together for optimal communication and best management of a pregnant patient and her fetus/child [2].

Imaging during pregnancy

Nowadays, the diagnosis of lumbar disc herniation is established by obtaining a dedicated standard spine MRI, which is usually performed in axial and sagittal T1 and T2 sequences.

It is important to reiterate that pregnancy is not considered a contraindication for MRI scanning [9, 25, 47]. MRI is a useable and highly valuable diagnostic tool in pregnant woman since it permits a detailed spinal examination without the ionizing effects of x-rays with its intrinsic biologic risk to the developing fetus. The most recent relevant paper on the subject states: “Exposure to MRI during the first trimester of pregnancy compared with nonexposure was not associated with increased risk of harm to the fetus or in early childhood. Gadolinium MRI at any time during pregnancy was associated with an increased risk of a broad set of rheumatological, inflammatory, or infiltrative skin conditions and for stillbirth or neonatal death” [47]. Of note, no contrast is required for the radiological diagnosis of lumbar disc herniation using MRI, and hence late risk can be avoided.

We therefore want to emphasize our impression that neither MRI [34] nor surgical lumbar disk excision is contraindicated at any stage of gestation [11, 25, 26, 32].

Trimester-based management

The choice of the position was seemingly influenced by the status and stage of the pregnancy. During the first and second trimester, surgery can still be performed easily when the patient is carefully placed in the prone position. However, if done later in pregnancy (especially during the third trimester), surgery in the prone position is not suitably performed because of the gravid uterus [4, 21]. It has been well established that in late stages of pregnancy (over 30 weeks) the left lateral decubitus is the best position to prevent hypotension as it avoids compression of the inferior vena cava [29, 49] (Fig. 3).

It is then necessary to decide whether the pregnancy can be continued to allow delivery close to term or whether surgical intervention cannot be delayed any further and the pregnancy should be interrupted, delivering the child by cesarean section.

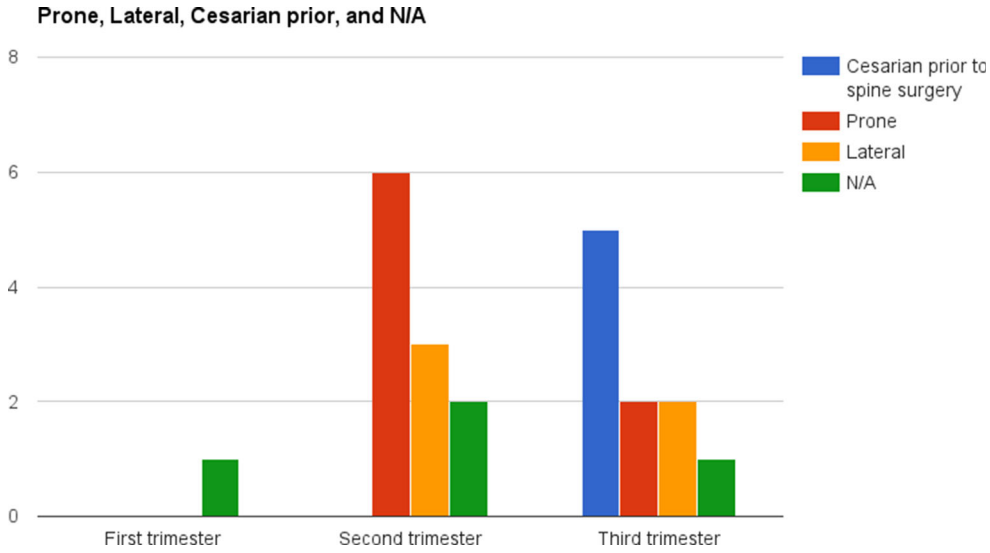

Fig. 3 Patient position during surgery in relation to trimester of pregnancy (reviewed data)

If the pregnancy is too early to ensure a viable fetus ex utero and the decision is made to continue the pregnancy, surgery is performed in the left lateral position for all cases in the late second or third trimester [4]. Another option is to end pregnancies that have advanced to the 25th week or later so that early delivery via cesarean section can be attempted. In such a scenario, spine surgery in the prone position can be performed immediately following the delivery of the child, often even during the same anesthesia.

We extracted from the published papers the information that 6 out of 11 women who were operated on during the early second trimester were positioned prone for surgery. In the third trimester, cesarean section was performed most of the time prior to any spine surgery, which was done during the same intervention in 50% (5/10) of cases.

Indeed, if pregnancy is advanced enough, cesarean section usually leads to the delivery of a healthy and well-developed infant. However, such a management is of course not possible during the early part of the second trimester.

According to available data and in agreement with a management suggestion by Ochi and colleagues [44], we developed the updated algorithm for management of lumbar disc

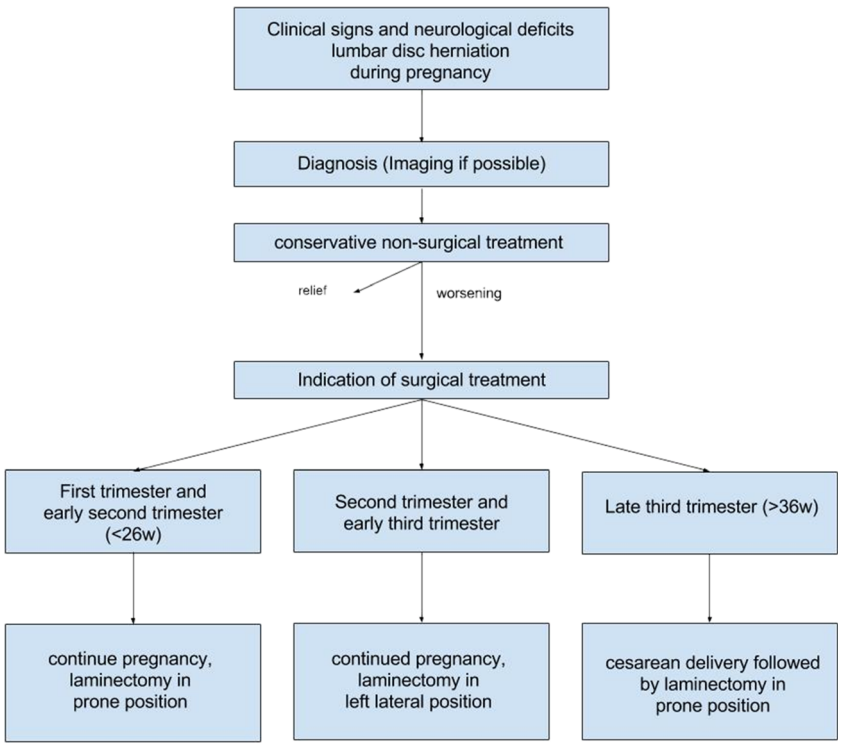

Fig. 4 Algorithm for surgical management of lumbar disc herniation during pregnancy

herniation during pregnancy in relation to the patient's pregnancy status by trimesters (Fig. 4). We emphasize that this algorithm is based on a relatively small cohort of reviewed single case reports. Therefore, we suggest this general management strategy with the clear understanding that it needs to be carefully reevaluated and possibly modified for individual cases. Clinicians needs to be mindful of the fact that the results from available clinical data are not derived from well designed and controlled studies but collected from a large number of reports of rather low evidence level which needs to be taken into account when making decisions for future patients.

Conclusion

In this narrative review on surgery for lumbar disk herniation during pregnancy, a number of crucial aspects were examined that identified the currently practiced management. In general, spine surgery for a herniated disk can be performed safely for the mother and child when the situation is well managed by an interdisciplinary team.

Our proposed management guidelines are based on stratification of patients according to the stage of pregnancy: for gestational ages less than 26 weeks, we recommend to proceed with management as for the general population. If the pregnancy is close enough to term to allow for a viable fetus to be born, delivery of the child should be the goal (which can be achieved without significant added risk to the mother). Here, once gestational age has advanced beyond 34 weeks, cesarean section under general anesthesia followed by immediate surgery for the neurosurgical problem is advised. As for gestational weeks 25 to 34, this is probably the more complicated period. Here, neurosurgical intervention should proceed as deemed necessary with a clear emphasis on safe surgery. If the fetus remains viable following surgery (as it likely will) and the pregnancy is stable, the goal should be to allow the pregnancy to continue to term.

Compliance with ethical standards

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Conflict of Interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

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