Effect of lateral tilt angle on the volume of the abdominal aorta and inferior vena cava in pregnant and nonpregnant women determined by magnetic resonance imaging

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Title: Effect of lateral tilt angle on the volume of the abdominal aorta and inferior vena cava in pregnant and non-pregnant women determined by magnetic resonance imaging

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Abstract

Background: The left-lateral tilt position is used to reduce aortocaval compression by the pregnant uterus and maintain stable maternal hemodynamics based on the unvalidated assumption that this decreases abdominal aorta and inferior vena cava (IVC) compression.

Methods: Magnetic resonance images of 10 singleton parturients at full-term (37-39 weeks gestation) and 10 healthy non-pregnant women were obtained for measurement of the abdominal aorta and IVC volume between the L1/2 disk and L3/4 disk levels in both the supine and left-lateral tilt positions (15°, 30°, and 45°) maintained by insertion of a 1.5-m long polyethylene foam placed under the right side of the parturient's body from head to toe. Mean arterial pressure and cardiac output were also measured in each position based on thoracic bioimpedance.

Results: Aortic volume did not differ significantly between parturients and non-pregnant women in the supine position (12.7±2.0 *vs.*12.6±2.1 ml, mean ± SD; mean difference, -0.1; 95% CI, -2.0 to 1.9; *P*=0.95). IVC volume in the supine position was significantly lower in parturients than in non-pregnant women (3.2±3.4 *vs.*17.5±7.8 ml; mean difference, 14.3; 95% CI, 8.3 to 20.2; $P<0.001$). Aortic volume in parturients did not differ among left-lateral tilt positions. IVC volume in the parturients was not increased at 15° (3.0±2.1 ml; mean difference, -0.2; 95% CI, -1.5 to 1.2; $P>0.99$), but was significantly increased at 30° (11.5±8.6 ml; mean difference, 8.3; 95% CI, 2.3 to 14.2; $P=0.009$) and 45° (10.9±6.8 ml; mean difference, 7.7; 95% CI, 2.2 to 13.1; $P=0.015$). Aortic and IVC volumes in non-pregnant women did not differ between left-lateral tilt positions. Arterial pressure and cardiac output did not differ significantly between parturients and non-pregnant women.

Conclusions: In parturients, the aorta was not compressed, and a 15° left-lateral tilt position did not effectively reduce IVC compression.

Introduction

Compression of the inferior vena cava (IVC) during late pregnancy when parturients are in the supine position has been well recognized as a possible cause of supine hypotensive syndrome since the report of Howard et al. in 1953.[1] Angiograph and magnetic resonance imaging (MRI) have directly demonstrated that IVC is almost completely compressed by the gravid uterus in the supine position and that IVC compression is reduced in the left-lateral position.[2-4] Further, in the late 1960s, Bieniarz et al. energetically performed angiography and simultaneously measured brachial artery and femoral artery pressure of pregnant women, and advocated that, similar to the IVC, the abdominal aorta and its branches are compressed by the gravid uterus when parturients are in the supine position.[5-8] Since then, compression of the abdominal aorta by the gravid uterus has been widely accepted among anesthesiologists and obstetricians, and both IVC and aortic compression together are referred to as aortocaval compression.[9,10]

Aortocaval compression can cause hemodynamic disturbances and uteroplacental hypoperfusion in parturients. Because the left-lateral position is impractical in clinical situations, a left-lateral tilt position is often promoted to reduce aortocaval compression by the pregnant uterus.[11-17] The recommended tilt angle is reported to be 15° following spinal anesthesia for cesarean section[12-15] and 30° during resuscitation in pregnant women, [16,17] although these recommended angles remain controversial.[18-21] The assumption that the left-lateral tilt position decreases aortocaval compression, however, has never been morphologically validated. We used MRI to examine whether the left-lateral tilt position reduces aortocaval compression based on measurements of the aortic and IVC volumes. The purpose of the present study was to investigate the effect of the lateral tilt angle (15°, 30°, and 45°) on the volume of the abdominal aorta and IVC in pregnant and non-pregnant women.

Materials and Methods

Following approval by the Hospital Ethics Committee (Tokyo Women's Medical University Hospital in Tokyo, Japan), written informed consent was obtained from 10 healthy women with cephalic singleton pregnancies at full-term (37-39 weeks gestation) and 10 non-pregnant healthy female volunteers. Pregnancy was confirmed by ultrasound and report of last menstruation. Non-pregnant women had negative pregnancy test results and reported menstruation in the previous 4 weeks. Women with obesity (body mass index>30), cardiovascular disease such as hypertension (systolic blood pressure>140 mmHg), a known fetal abnormality, and those women who were unable to lie in the supine position in the MRI because of supine hypotensive syndrome or claustrophobia, were excluded from recruitment.

Sagittal MRI images of the abdomen were obtained to determine the portal hepatic region and the spinal level was identified. Abdominal axial MRI images from the portal hepatic region to the middle of the pelvis for measurement of the volume of the abdominal aorta and IVC in either the supine or left-lateral tilt position at 15°, 30°, and 45° were obtained using an MRI system (Magnetom Symphony, Siemens, Tokyo, Japan) operating at 1.5 T at 2.3-mm increments with a fast-spin echo sequence, which highlights the aorta and IVC. Briefly, the technical specifications included a 1500-ms repetition time (TR), 146-ms echo time (TE), 40×34-cm field of view, 320×320-image matrix, and 1.5-mm slices at 0.8-mm intervals. The left-lateral tilt position was supported by a 1.5-m long hard V-block constructed of closed-cell polyethylene foam that extended from head to toe under the right side of the subject's body. Although it was visually confirmed that the right side of the subject's body was properly positioned on the foam, the angle of the body was not assessed directly using a protractor. The subjects were first positioned supine, then at 15°, 30° and 45° in order. The time required to obtain sagittal and axial MRI images at each position was 45 s, and 6 min and 36 s, respectively.

One of the authors (S.T.) determined the areas of the aorta and

IVC from the L1/2 disk level to the L3/4 disk level for each axial MRI image using the public domain Osirix Imaging Software 5.8.5 (developed by Pixmeo, a Geneva based company, Bermex, Switzerland).[#] The images were encoded and randomized to blind the investigator to the object of the present study and the source of the image with regard to pregnancy. The area of the axial section was each multiplied by the interval between slices (2.3 mm) to calculate aortic and IVC volumes from the L1/2 disk level to the L3/4 disk level. The volume from L1/2 disk level to L3/4 disk level was chosen for two reasons; standardization and limitations of the images. MRI slices in different positions and/or subjects were not necessarily at the same level; disk levels were selected as a reference for anatomic segmentation in each subject. Although axial MRI images from the portal hepatic region to the middle of the pelvis were obtained in this study, measurements of the aortic and IVC volume were based only on images from the L1/2 disk level to the L3/4 disk level. Below the portal hepatic region to the L1/2 disk

[#] Available at: http://www.osirix-viewer.com/ Accessed Aug 23, 2014.

level, there are many adjacent structures, such as the diaphragm, descending part of duodenum, and right renal vein, around the IVC. Accordingly, it was impossible to detect the IVC because of the limited resolution of the MRI in the present study. At the L1/2 disk level, it is possible to detect the IVC with difficulty. Below the L3/4 level, the aorta and IVC branch to the external and internal iliac arteries and veins, respectively.

Cardiac output (CO), mean arterial pressure, and heart rate were measured in each position using the thoracic bioimpedance technique just before or after MRI using bioimpedance cardiography with the BioZ instrument (Cardio Dynamics International, San Diego, CA). The cuff of an automated noninvasive blood pressure device was attached to the right arm. After 5 minutes of rest, CO, blood pressure and heart rate were measured three times at 1-minute intervals in the supine position. The mean value of the second and third readings was recorded as the baseline value. After changing to each position, the women were allowed to rest for 3 minutes before any measurements were obtained and then these parameters were measured twice and averaged.[22]

Statistical Analysis

Power analysis (α=0.05, β=0.20) indicated that a subject sample size of 11 per group was needed to reveal a significant difference in the IVC volume of supine pregnant women compared to those in the left-lateral tilt position at 30°, assuming that the difference in the IVC volume between the two points was 8.0 ml ± 4 (mean ± SD), which was based on a preliminary study. As the data were collected with 10 subjects per group, unplanned interim analyses were implemented because of slow recruitment (3y for the current study). The study was terminated because a significant difference was obtained. No attempts were made to adjust the significance level for the interim analyses. Data are expressed as mean ± SD or median (range) and analyzed using an unpaired test where appropriate. Inter- and intragroup comparisons were analyzed using a two-way repeated measures analysis of variance followed by the Dunnett *post hoc* test for multiple comparison. A *P* value of less than 0.05 was considered statistically significant (two-tailed). Statistical analyses were performed with JMP 11.0.0 software (SAS Institute, Cary, NC).

Results

Characteristics of the 20 women (10 each) included in the study are presented in Table 1. Except for body weight ($P<0.05$), there were no significant differences in measurements between the pregnant women and the non-pregnant women. In 7 of 10 pregnant women, the fetus was in the right occiput position, and in the other 3 parturients, the fetus was in the left occiput position (Table 2).

In both parturients and non-pregnant women, the abdominal aorta could be easily identified by its round-shape and the volume was not significantly different in any of the left-lateral tilt positions, although the shape of aorta of parturients differed in some MRI slices (Figs.1-3). There was also no significant difference in the aortic volume between parturients and non-pregnant women in any of the left-lateral tilt positions (Table 1).

In the non-pregnant women, the IVC was not compressed in the supine position and the volume of the IVC did not change in any of the left-lateral tilt positions (Table 1, Fig.1). In contrast, the IVC was almost completely compressed by the gravid uterus in the supine position in all parturients (Figs.2, 3). The IVC volume in the supine position in parturients was significantly smaller than in non-pregnant woman (3.2±3.4 *vs.*17.5±7.8ml; mean difference, 14.3; 95% CI, 8.3 to 20.2; P<0.001:Table 1). The change in the IVC volume differed markedly in parturients among the left-tilt positions. (Table 2. Figs. 2, 3). In the 15° left-tilt position, IVC volume was somewhat decreased in 5 of 10 parturients compared with that in the supine position (Table 2). Overall, the IVC volume in parturients did not significantly differ between the supine position and the 15° left-tilt position (3.0±2.1 ml; mean difference, -0.2; 95% CI, -1.5 to 1.2; P>0.99:Table 1). In the 30° left-tilt position, the IVC volume in all parturients increased, compared with that in the supine position, although the extent of the increase varied (Table 2). As a result, IVC volume was significantly different between the supine position and the 30° left-tilt position (11.5±8.6 ml; mean difference, 8.3; 95% CI, 2.3 to 14.2; P=0.009:Table 1). In the 30° left-tilt position, the IVC volume was also significantly different between parturients and non-pregnant women (21.5

± 6.2 ml; mean difference, 10.1; 95% CI, 2.8 to 17.2; *P*=0.009:Table 1). Although the IVC volume in the 45° left-tilt position (10.9 ± 6.8 ml) was significantly increased compared that with in the supine position (mean difference, 7.7; 95% CI, 2.2 to 13.1; *P*=0.015), the IVC was not significantly different between the 45° left-tilt and 30° left-tilt position positions (Table 1). Parity and side of the fetal spine in the uterus were not significantly related to the IVC volume (Table 2).

The site of aortic bifurcation (the abdominal aorta bifurcates into the right and the left common iliac arteries) varied among subjects (Tables 1,2). Thus, it was not possible to compare the sizes of the aorta and iliac artery in parturients in the supine position with those in the left-lateral tilt position in parturients and/or in non-pregnant women because of the lack of a reference for anatomic segmentation in each subject. The lower abdominal aorta just proximal to the bifurcation appeared to remain round-shaped, and was not compressed in all parturients in the supine position (Fig.2) and the bilateral common iliac arteries were also not compressed in 5 parturients in the supine position (Fig.3).

CO, mean arterial pressure and heart rate were not significantly different among tilt angles in either group. In addition, the intergroup differences in CO, mean blood pressure and heart rate at any angle were not significantly different between pregnant and non-pregnant women (Table 3).

Discussion

Aortic volume did not differ between parturients and non-pregnant women at any angle examined. IVC volume in parturients differed according to the tilt angle, but IVC volume did not differ significantly between the 15°left-lateral tilt position and the supine position. In 1977, Hirabayashi et al. reported total IVC compression in parturients in the supine position, which was reduced in the left-lateral position.[4] In their study, however, only three parturients were examined and only three MRI images were obtained per parturient. Further, the volumes of the abdominal aorta and IVC were not measured in left-tilt lateral positions. In the present study, however, many MRI images (approximately 140 images per woman) were obtained and the volumes of the aorta and IVC were measured in multiple left-tilt lateral positions (15°, 30°, and 45°).

In 1935, Coutts et al. performed abdominal aortography in late pregnant women and reported filling defects in the common iliac arteries.[23] In the late 1960s, Bieniarz et al. also performed abdominal aortography in late-term pregnant (over 32 weeks gestation) women and reported that the aorta is less densely opacified in the region of lumbar lordosis L4/5 during uterine relaxation, and that the common iliac artery crossing the vertebra at L4/5 is transiently occluded during uterine contraction in the anteroposterior views. [5-8] Although the lateral angiograms obtained in their study demonstrated that aortic narrowing just at the level of lumbar lordosis, they did not quantify aortic size or report how many parturients exhibited aortic narrowing. [5-8] In their series, Bieniarz et al. also reported that brachial artery pressure was higher than that recorded simultaneously in the femoral artery. Based on these findings, they concluded that the abdominal aorta and its branches were compressed by the gravid uterus in the supine position and demonstrated an imaginary cross-section illustration of the abdominal cavity at the L4 level where the aorta and IVC was similarly remarkably compressed.[5-8] The illustrations of Bieniarz et al., showing a flattened aorta, were later modified and widely presented in many articles [24,25] and textbooks.[26, 27] Accordingly, many anesthesiologists and obstetricians, including us, have long held a firm belief that the abdominal aorta is compressed by the gravid uterus. Our findings, however, revealed that the volume of the abdominal aorta in parturients from the L1/2 to L3/4 disk level did not differ from that in non-pregnant women in the supine position (Table 1). Further, axial MRI revealed that the lower abdominal aorta just proximal to the bifurcation remained round in all parturients in the supine position (Fig.3). To the best of our knowledge, this is the first study to evaluate and quantify the abdominal aorta in parturients based several cross-sectional images. Unfortunately, we were unable to evaluate bilateral common iliac arteries distal to the bifurcation because of the low resolution of the MRI.

Although pregnant woman would ideally maintain a full lateral position to avoid hemodynamic disturbances and uteroplacental hypoperfusion, this position is not practical for surgical access. Thus, the lateral table tilt or pelvic tilt position was introduced in clinical practice in the 1970s. In 1970, Ansari et al. reported improved oxygen saturation of umbilical blood in the 10° left-lateral tilt position, especially under spinal anesthesia.[11] The present common recommendation, first described by Crawford et al. in 1972, is a 15° lateral tilt, achieved using a wedge-shaped cushion.[28] They demonstrated that placing a cushion (angle of upper plane was 15°) under the hip of mothers to tilt the pelvis to the right or the left under general anesthesia, significant improved the fetal acid-base status. Others also reported improved maternal hemodynamics (CO and stroke volume) in the 15° left-lateral tilt position. [12,15] Further, the maximal lateral tilt of a traditional operating table is 15°. [29] On the other hand, several studies found no improvement in maternal hemodynamics or fetal parameters with parturients in 15° to 20° left-lateral tilt positions.[18, 21, 30] The 15° tilt is disappointingly ineffective for preventing hypotension during spinal anesthesia for caesarean section.[20, 31] In the present study, mean IVC volume in parturients did not differ significantly between the supine and 15° left-tilt positions, although IVC volume varied among parturients. These findings may partly explain the conflicting results regarding the effect of the 15° left-tilt position on maternal hemodynamics or fetal parameters and the failure to prevent hypotension during spinal anesthesia.

In contrast to the 15° left-tilt position, IVC volume was significantly increased while in the 30° and 45° tilt positions. These findings might support the American Heart Association guideline for resuscitation of parturients.[17] The American Heart Association recommends positioning pregnant patients in a left-lateral tilt of 27° to 30°, by using a firm wedge to support the pelvis and thorax, such as a Cardiff resuscitation wedge, [16] if the manual left uterine displacement technique is unsuccessful (Class II b, Level of Evidence C). [17] A tilt of 30° or more, however, may cause the patient to slide or roll off the inclined plane and the compression force will gradually decrease, compared with that at a tilt of 27°. [16] Although the compression force at an angle of 27° is 80% of that in the supine position, the corresponding value at the angles of 32°, 49° and 90° is 70%, 62% and 54%, respectively.[16] In the present study, IVC volume did not differ significantly between in the 30°and 45° left-tilt positions, indicating that a tilt angle greater than 30° may not be necessary during resuscitation.

CO was chosen as our hemodynamic outcome measure because it is directly affected by aortocaval compression.[15, 29, 32] In the present study, we measured CO based on thoracic bioimpedance, which is a complex dynamic process to indirectly calculate CO based on simplistic assumptions.[32] This method of CO measurement is affected by changes in patient position and may thus be inaccurate as a result.[33] Although it is reported that CO increases with gestation to a maximum at about 30 weeks of 50% above that in non-pregnant controls and decreases until term to 32% above non-pregnant levels,[34,35] we detected no significant difference in CO between pregnant and non-pregnant women in the present study. The failure to demonstrate a significant difference in CO might be due to the inaccuracy of the thoracic bioimpedance technique or the small number of patients included in the present study. In addition, CO did not differ significantly among parturients in any of the positions, although IVC volume at 30°and 45°was significantly increased compared with that in the supine position. Healthy parturients could also have compensation mechanism for caval compression. All parturients were able to lie in the supine position without any hemodynamic symptoms, such as hypotension.

The present study has several limitations. First, pregnant and non-pregnant women in the present study were not anesthetized. Accordingly, their abdominal muscles were not relaxed. If abdominal muscle relaxation is obtained, the pregnant uterus may displace to the left to a greater extent than observed in the present study. In addition, vasodilation did not occur because the sympathetic nervous system was not blocked. Further, the effect of intravenous fluid cannot be eliminated. In the present study, none of the subjects received intravenous fluid during the MRI and measurement of hemodynamic data. Second, parturients were not in labor. Aortic compression is reportedly more evident during labor.[6, 8,15] If MRI images are obtained during uterine contraction, different images of the arteries may be obtained. Third, to avoid complicated procedures, the order of the positions was consecutive and not randomized. Hemodynamic data resulting from a position change should be obtained in a randomized order to account for acclimatization.[15, 33] Acclimatization due to the consecutive order of the positions in the present study could partly explain the failure to detect a significant difference in the hemodynamic data based on the tilt angle. There are no reports, however, that morphology acclimates. Fourth, the enrolled parturients were healthy Japanese women, who were quite slender by the standards of many Western countries. In parturients with aortocaval compression syndrome, pregnancy-induced hypertension, obesity, or other co-morbidities, the results might differ. Fifth, unplanned interim analyses were conducted without *P* value adjustments of statistical significance. We should have performed planned interim analyses in which statistical significance was obtained below a Bonferroni adjusted *P* value of 0.025. We believe, however, that it is unlikely that we made a type I error, because statistically significant *P* values were obtained in unplanned, post *hoc* adjustments. Finally, the resolution of the MRI images was low. Because the boundaries of the adjacent structures were not clear, there are many sources of error in MRI, especially when measuring the IVC area. In addition, we could not evaluate the bilateral common iliac arteries distal to bifurcation. Further studies using MRI with improved resolution are required to investigate the effect of the lateral tilt position on the IVC, aorta, and their branches.

In conclusion, aortic volume in parturients did not differ among left-lateral tilt positions and did not differ from those in the non-pregnant woman. The IVC volume in parturients was not increased at 15° compared with that in the supine position, whereas the corresponding values were significantly increased at 30° and 45°.

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Table 1. Patient characteristics and magnetic resonance imaging measurements in the pregnant and non-pregnant women

	Pregnant (n=10)	Non-pregnant (n=10)
Age (yr)	34 ± 5	34 ± 4
Height (cm)	160 ± 5	160 ± 6
Weight (kg)	57 ± 8*	49 ± 4
Gestational age (week)	39 (37-39)	-
Parity (0/1)	6/4	8/2
Level of aortic bifurcation		
L4	9	5
L4/5	0	1
L5	1	4
Aorta volume (ml)		
0°	12.7 ± 2.0	12.6 ± 2.1
15°	12.7 ± 2.1	12.6 ± 2.1
30°	12.9 ± 1.8	12.7 ± 1.8
45°	13.2 ± 2.2	12.3 ± 1.7
Inferior vena cava volume (ml)		
0°	3.2 ± 3.4***	17.5 ± 7.8
15°	3.0 ± 2.1***	19.7± 6.0
30°	11.5 ± 8.6** ‡	21.5 ±6.2
45°	10.9 ± 6.8** ‡	20.6 ± 5.0

Values are mean ± SD, median (range) or number of women.

*P<0.05, **P<0.01, ***P<0.001 compared with each value in the nonpregnant women. ‡ P<0.05 compared with each value in the supine position (0°).

Table 2. Individual parturient characteristics and the changes in the IVC volume in parturients

	Age (yr)	BMI (kg/m^2)	Gestational age (week)	Parity	Side of fetal spine	Level of aortic bifurcation	IVC volume (ml)			
							0°	15°	30°	45°
1	42	23.2	39	1	Right	L5	0.7	3.0	26.1	21.4
2	24	20.1	39	0	Right	L4	1.8	1.5	1.9	0.9
3	31	17.8	39	0	Right	L5	0.4	0.5	1.4	2.4
4	32	26.2	39	0	Right	L4/5	9.7	5.2	23.5	10.8
5	31	25.2	38	0	Right	L4	0.3	1.7	16.3	15.8
6	36	19.3	39	1	Right	L4	1.2	1.2	13.5	18.5
7	37	22.7	39	1	Left	L5	3.3	2.2	6.8	12.4
8	37	21.8	38	0	Right	L5	6.6	6.5	12.5	13.0
9	31	21.6	38	0	Left	L4	1.1	2.6	3.6	4.7
10	35	25.6	37	1	Left	L4	7.1	5.9	9.3	9.0

BMI = body mass index, IVC = inferior vena cava

Table 3. Hemodynamic measurements in the pregnant and non-pregnant women

	Pregnant (n=10)	Non-pregnant (n=10)
Cardiac output (L/min)		
0°	5.4 ± 0.9	4.6 ± 0.8
15°	5.6 ± 0.9	4.7 ± 0.7
30°	5.3 ± 0.9	4.5 ± 0.6
45°	5.4 ± 1.1	4.5 ± 0.6
Mean arterial pressure (mmHg)		
0°	77 ± 8	76 ± 8
15°	80 ± 8	77 ± 5
30°	78 ± 9	76 ± 5
45°	80 ± 10	75± 6
Heart rate (beats/min)		
0°	81 ± 14	72± 4
15°	79 ± 13	73± 7
30°	79± 14	69 ±5
45°	81± 14	71 ± 6

Values are mean ± SD. Cardiac output, mean arterial pressure, and heart rate were not significantly difference in among the different positioning angles in each group or between pregnant and non-pregnant women.

Figure legends

Figure 1: Magnetic resonance images of a 31-year-old non-pregnant woman in either the supine (*A* and *E*), or left-lateral tilt position at 15°(*B* and *F*), 30°(*C* and *G*), or 45°(*D* and *H*) at the L3/4 disk level (*A-D*) and L4/5 disk level (*E-H*). (*A-D*) Neither the aorta (solid arrow) nor IVC (outlined arrow) changed in size or shape sin any position. Area of the aorta and IVC at each level was 1.4, 2.0 cm^2; 1.5, 2.1 cm^2; 1.6, 2.4 cm^2; and 1.5, 2.4 cm^2, respectively. The IVC area at each level was 2.0, 2.1, 2.4, and 2.4 cm^2, respectively. (*E-H*) The size of the IVC changed slightly according to the position. The IVC area at each level was 1.9, 1.4, 1.2, and 1.8 cm^2, respectively. Right and left common iliac arteries (dashed arrow), which were divided from the abdominal aorta, were identifiable in any position. Area of the right and left common iliac arteries at each level was 0.7, 0.8 cm^2, 0.5, 0.6 cm^2, 0.8, 0.7 cm^2, and 0.7, 0.7 cm^2, respectively. In these axial images,

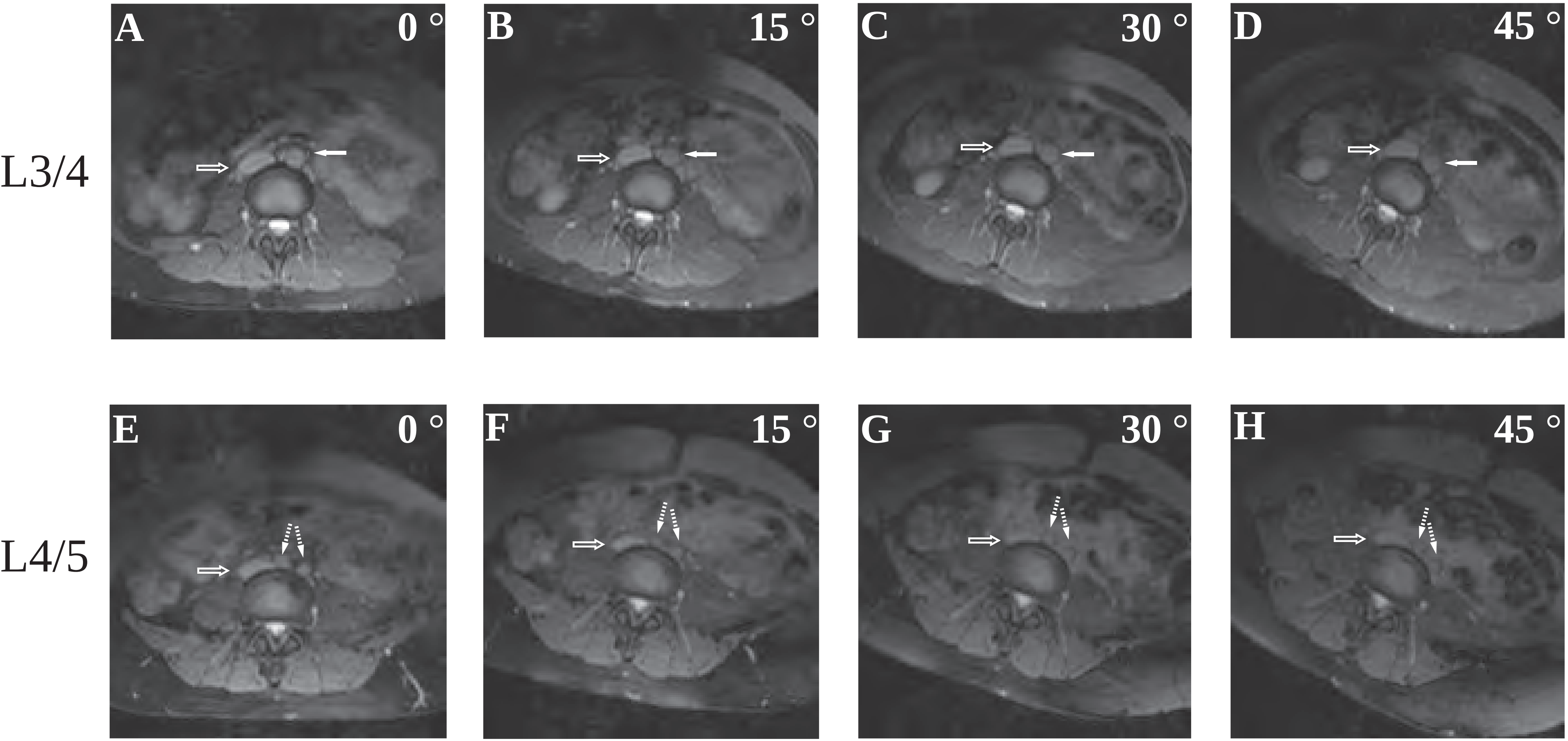
anterior is at the top of the figure and anatomic right is to the left in the figure.

Figure 2: Magnetic resonance images of a 42-year-old pregnant woman (the fetus was in the right occiput position; patient No.1) in either the supine position (*A* and *E*), or the at 15°(*B* and *F*), 30°(*C* and *G*), or 45°(*D* and *H*) left-lateral tilt positions at the L2/3 disk level (*A*-*D*) and L4/5 disk level (*E*-*H*). (*A*-*D*) Aortic size (solid arrow) did not change significantly in any position. Aortic area at each level was 1.3, 1.3, 1.2, and 1.0 cm^2, respectively. The inferior vena cava (IVC; outlined arrow) was almost completely compressed and the shape appeared band-like in the supine position. In the 15° left-lateral tilt position, the fetus was moved to the left, slightly reducing IVC compression. IVC compression was significantly reduced in the 30° left-lateral tilt position. The IVC area at each level was 0.2, 0.5, 2.1, and 1.8 cm^2, respectively.

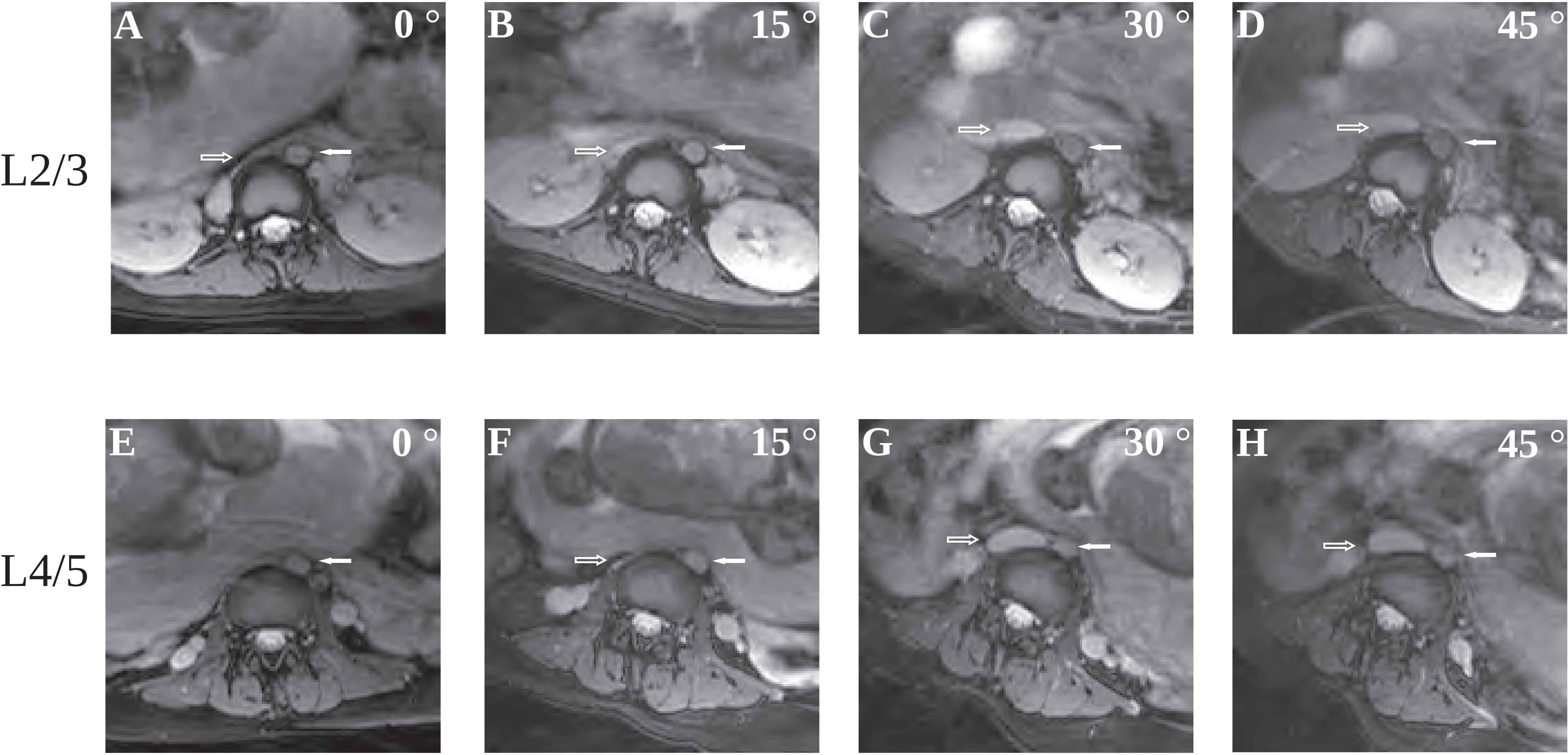
(*E-H*) The IVC was not identifiable in the supine position. In the 30° and 45° left-lateral tilt positions, IVC compression was significantly reduced. The IVC area at each level was 0.0, 0.5, 3.5, and 3.0 cm^2, respectively. The abdominal aorta did not divide to the common iliac artery at this level. The aorta was slightly deformed in the 15°, 30° , and 45° left-lateral tilt positions. Aortic area at each level was 1.2, 1.0, 1.0, and 0.9 cm^2, respectively. In these axial images, anterior is at the top of the figure and anatomic right is to the left in the figure.

Figure 3: Magnetic resonance images of a 31-year-old pregnant woman (the fetus was in the left occiput position; patient No.9) in either the supine position (*A* and *E*), or at the 15°(*B* and *F*), 30°(*C* and *G*), or 45°(*D* and *H*) left-lateral tilt positions at the L3/4 disk level (*Top*) and L4/5 disk level (*E-H*). (*A-D*) The aorta (solid arrow) was slightly compressed in the 15° left-lateral tilt position and

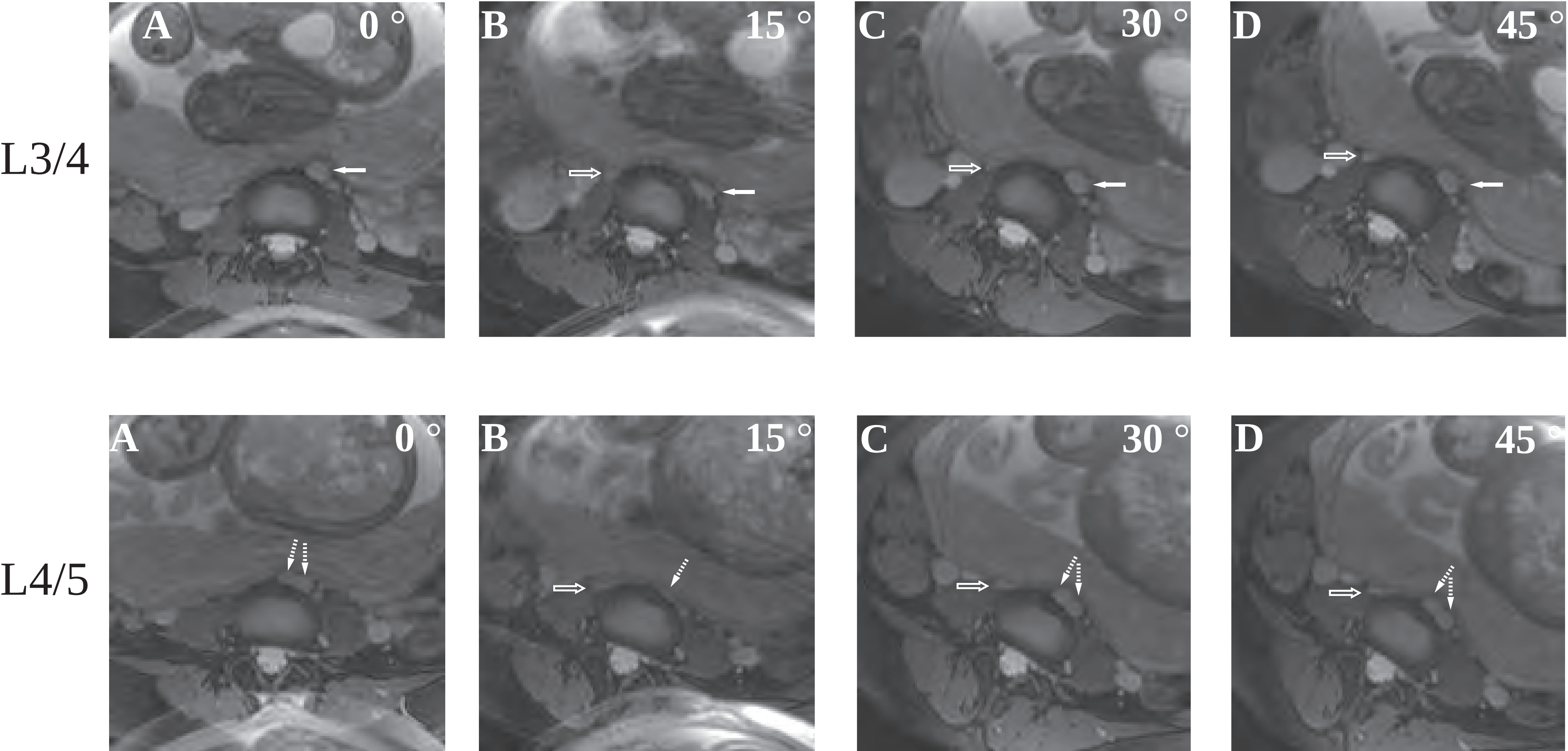
deformed in the 30°, and 45° left-lateral tilt positions. Aortic area at each level was 1.0, 0.8, 1.0, and 1.0 cm^2, respectively. The inferior vena cava (IVC) (outlined arrow) was not identifiable in the supine position. Although the fetus was gradually moved to the left side of the abdominal cavity as the tilt angle increased, the IVC remained significantly compressed. The IVC area at each level was 0.0, 0.2, 0.2, and 0.2 cm^2, respectively. The arch shadow observed in the lower images in the supine and 15° left-lateral tilt positions is artifact. (*E*-*H*) Findings of the IVC at this level were the same as those at the L3/4 disk level. The IVC at each level was 0.0, 0.3, 0.3,and 0.3 cm^2, respectively. Right and left common iliac arteries (dashed arrow), which were divided from the abdominal aorta, were identifiable in the supine position, and at the 30°, and 45° left-lateral tilt positions. In the 15° left-lateral tilt position, common iliac arteries were compressed and appeared band-like. Area of the right and left common iliac artery at each level was 0.6, 0.7 cm^2 (0°), 0.7, 0.7 cm^2 (30°), 0.7, 0.7 cm^2 (45°), respectively. In these axial images, anterior is at the top of the figure and anatomic right is to the left in the figure.



L3/4
A
0 °
B
15 °
C
30 °
D
45 °
L4/5
E
0 °
F
15 °
G
30 °
H
45 °



L2/3
A
0 °
B
15 °
C
30 °
D
45 °
L4/5
E
0 °
F
15 °
G
30 °
H
45 °


L3/4
A
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L4/5
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