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RECOMMENDATIONS /*Obstetric imaging*

A proposal for standardized magnetic resonance imaging (MRI) descriptors of abnormally invasive placenta (AIP) — From the International Society for AIP☆

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KEYWORDS
Abnormally invasive placenta (AIP);

Abstract Abnormally invasive placenta (AIP) is used to describe a placenta that does not separate naturally after delivery and cannot be extirpated without causing abnormally high blood loss. Recently, the use of a standardized terminology for descriptors of AIP signs seen

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Magnetic resonance imaging (MRI); International Society for AIP

on ultrasound has been prosed but to date no such unified descriptors have been developed for magnetic resonance imaging (MRI). The purpose of this paper is to propose a unified terminology based on a consensus opinion from the members of the International Society for AIP (IS-AIP) that include obstetricians, gynecologists, radiologists, pathologists, anesthesiologists and basic science researchers. We assume that using these standardized MRI descriptors for AIP will be useful for clinical use, education, teaching and future research projects, thus assumably improving care of patients with this condition. In addition, using a uniform terminology for AIP should become the first step of a standardized MRI report.

Abnormally invasive placenta (AIP) is used to describe a placenta that does not separate naturally after delivery and cannot be extirpated without causing abnormally high blood loss. AIP is the consequence of an excessive invasion of the placenta within the myometrium. AIP may have different degrees of severity ranging histopathologically from placenta accreta (corresponding to abnormal adhesion of villous tissue that is attached directly to the underlying myometrium without interposing decidua) and placenta increta (corresponding to a deeper invasion of the myometrium) to placenta percreta (corresponding to invasion of adjacent organs, most often the bladder). Whatever the severity of placental invasion, AIP can be complicated by major and potentially life-threatening peripartum bleeding [1—3]. AIP is the leading cause of emergency obstetric hysterectomy in developed countries [4,5] and maternal mortality has been reported to be as high as 7% in the presence of AIP [6].

The principal risk factor for AIP is a pre-existing underlying uterine scar, which conveys a relative risk of 7 to 8. Uterine scar is predominantly the consequence of a previous cesarean section. Other risk factors have been identified, including placenta previa or prior uterine curettage [7—9]. The incidence of AIP increased tenfold over the last fifty years, as a consequence of a dramatic increase in cesarean section rates. Recent North-American studies have reported an incidence of AIP of 1 for 533 births [9—11]. With such a trend, it can be anticipated that the rate of cesarean sections in the United States of America will cause 4504 cases of AIP per year in 2020, and 130 annual maternal deaths [12].

Recently, the European working group on AIP (EW-AIP) has proposed the use of a standardized terminology for descriptors of AIP seen using ultrasound [13]. However, it is now well-established that magnetic resonance imaging (MRI) has an important role in the diagnosis of AIP [14—16]. Accordingly, the use of a standardized terminology for MRI is needed.

To improve comparability of future studies, to increase diagnostic capabilities and to facilitate international collaboration, the International Society for AIP (formerly the EW-AIP) proposes herein the use of standardized definitions of descriptors for AIP using MRI.

A plea for prenatal diagnosis of AIP

Maternal prognosis can be substantially improved by prenatal diagnosis of AIP [1,4]. The risk of bleeding is high in case of intra-partum diagnosis when forced placental extirpation is attempted. By contrast, when the diagnosis of AIP is made before delivery, birth can be planned in referral delivery ward where all necessary means (transfusion, interventional radiology, resuscitation and surgical skills) are available. Prenatal diagnosis also allows anticipating management strategies that will best meet the maternal expectations. Various surgical options can indeed be discussed depending on clinical specific situations and local experience, including conservative approach with a placenta left in situ in the absence of major bleeding, cesarean-hysterectomy or local resection of the placenta and placental bed [5—7].

However, prenatal diagnosis can be falsely positive, resulting in important iatrogenic consequences for the mother and the fetus. In such cases, cesarean section may be performed by median laparotomy under general anesthesia at a premature gestational age. It is recommended that women at risk of AIP have a prenatal specialized screening in order to be referred to a multidisciplinary referral center [1,8—10].

Imaging tools for the diagnosis of AIP

Ultrasound is the first-line imaging tool for the screening and diagnosis of AIP. However, the diagnostic capabilities of ultrasound are impaired by anatomical or physiological limitations such as unfavorable placental location or high maternal body mass index. In addition, the absence of standardized descriptors, until the recent proposal published by our group [13], might also have affected the performance of ultrasound in previous studies [14].

By contrast to ultrasound, the performance of MRI is not limited by the depth of examination. MRI can be performed in addition to ultrasound in order to improve the results of prenatal imaging [12]. In addition, full coverage of the pelvis by MRI allows reevaluation at anytime by different

Table 1 Unified descriptors for magnetic resonance imaging (MRI) findings in abnormally invasive placenta.

MRI finding	IS-AIP suggested standardized definition	Sequence type
Heterogeneous placenta	Heterogeneous signal within the placenta	T2W and T1W
Placental bulge	Deviation of uterine serosa from expected plane caused by abnormal bulge of placental tissue into neighboring organs (typically the bladder). Uterine serosa appears intact but outline shape is distorted	T2W and T1W
Dark intraplacental bands	One or more areas of hypointensity with a linear appearance, in contact with the maternal surface of the placenta	T2W
Placental ischemic infarction	Areas of increased signal intensity (T2W) and decreased signal intensity (T1W)	T2W and T1W
Loss of retroplacental dark zone	Loss of the thin dark lie beneath the placental bed	T2W
Myometrial thinning	Thinning of myometrium overlying the placenta to less than 1 mm or invisible	T2W
Bladder wall interruption	Irregularity or disruption of the normal hypointense urinary bladder wall	T2W
Focal exophytic mass	Placental tissue seen protruding through the uterine wall and extending beyond it. Most often seen inside a filled urinary bladder	T2W and TW1
Abnormal vascularization of the placental bed	Large vessels within the placental bed with disruption of the uteroplacental interface	T2W

AIP indicates abnormally invasive placenta; MRI indicates magnetic resonance imaging; T1W indicates T1-weighted image; T2W indicates T2-weighted image.

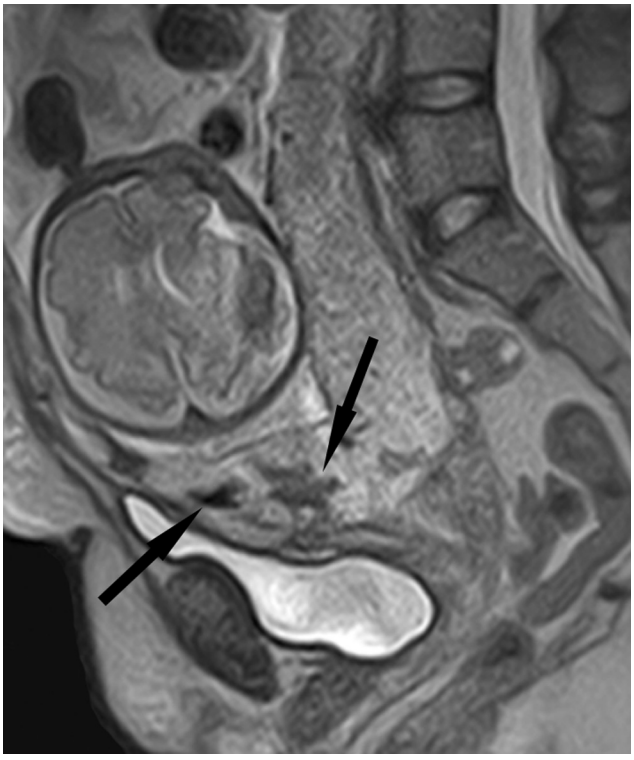

Figure 1. Heterogeneous placenta. 34-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 36 weeks of pregnancy. T2-weighted HASTE MR image in the transverse plane shows ill-defined dark areas conferring heterogeneous appearance (arrows). AIP was confirmed intraoperatively.

observers, which is a possibility that is usually not allowed by ultrasound. MRI, however, is more expensive and less available than ultrasound. MRI has been recommended as a second-line imaging tool since 2011 by the Royal College of Obstetrics and Gynecology [17]. The overall performance of MRI for the diagnosis of AIP was analyzed in a systematic review that included 11 studies in 2015 [18]. Of note, studies reporting the use of intravenous contrast-agents were excluded from the analysis [18]. Reported performance of MRI for the prenatal diagnosis of AIP had sensitivities ranging from 75 to 100%, specificity from 65 to 100%, positive predictive value from 67 to 94.4% and negative predictive value from 79 to 92% [14,19–28]. To date, MRI has not demonstrated superiority over ultrasound in the diagnosis of AIP [29]. However, it has been suggested that MRI might provide a more accurate evaluation of the degree of invasion for placenta percreta than ultrasound does, and especially for posterior AIP [30,31]. Early knowledge of this would facilitate the most appropriate multidisciplinary and surgical care.

Suboptimal performances of MRI for the diagnosis of AIP might be due in part to a lack of consensus regarding the terminology used for descriptors of individual abnormalities in AIP [32]. As with ultrasound, researchers often use personal descriptions for signs, so different terms may apply to the same observed abnormality [18]. It is therefore urgent to standardize the terminology to avoid further confusion. Furthermore, with MRI, descriptors are highly dependent on the MRI sequence used at the time of image acquisition, with marked variations among equipment and vendors. MRI performances also depend on the magnetic field used. To date, most publications have reported the results of MRI

Figure 2. Placental bulge. 39-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 36 weeks of pregnancy. T2-weighted HASTE MR image of the pelvis in the sagittal plane shows placenta previa, abnormal anterior placental bulging with no visible uteroplacental interface (arrows) and placental protrusion through serosa. Intraoperative findings confirmed severe AIP.

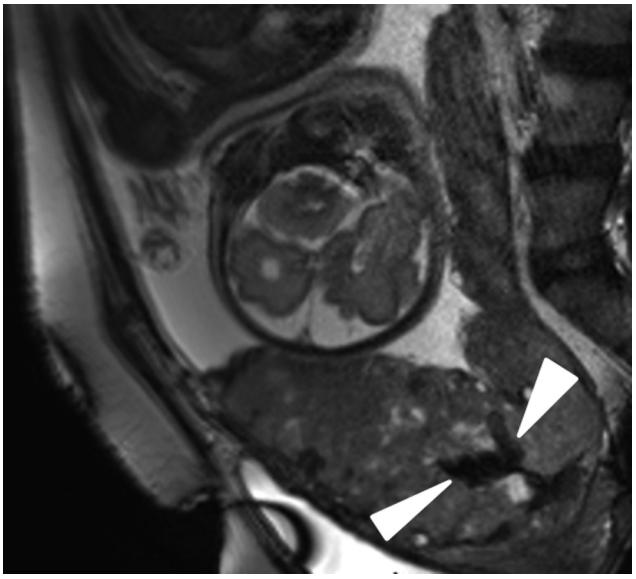

Figure 3. Intraplacental dark bands. 29-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 35 weeks of pregnancy. T2-weighted TrueFisp MR image of the pelvis in the sagittal plane shows placenta previa with intraplacental dark bands (arrowheads). Intraoperative findings confirmed AIP.

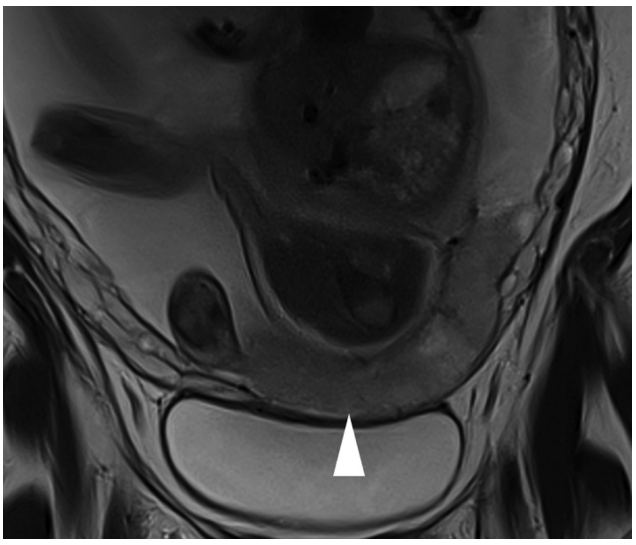

Figure 4. Loss of retroplacental dark zone. 35-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 32 weeks of pregnancy. T2-weighted BLADE MR image of the pelvis in the coronal plane shows placenta previa with focal loss of retroplacental dark band (arrowhead). Intraoperative findings confirmed AIP.

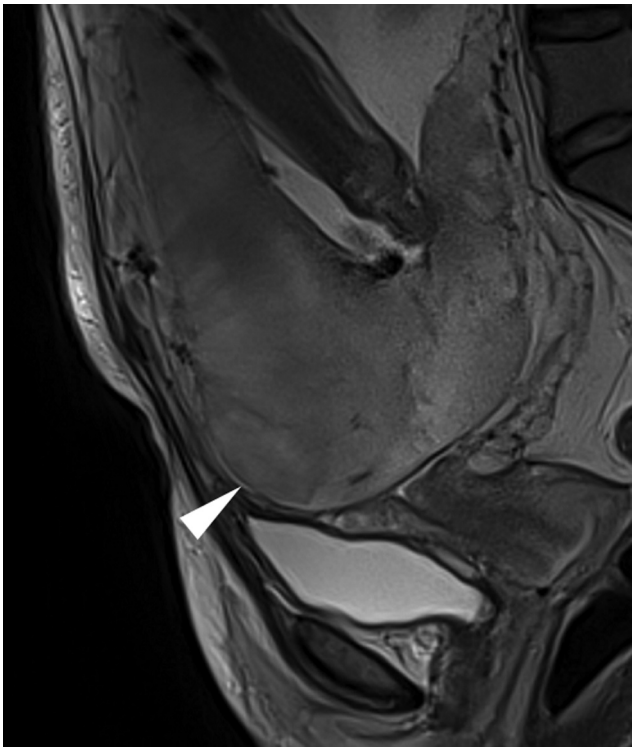

Figure 5. Myometrial thinning. 31-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 34 weeks of pregnancy. T2-weighted BLADE MR image of the pelvis in the sagittal plane shows placenta previa with myometrial thinning (less than 1 mm) (arrowhead). Intraoperative findings confirmed AIP.

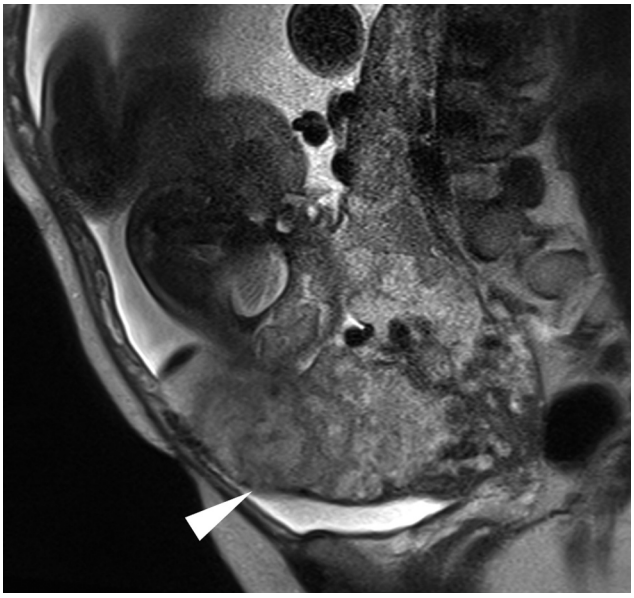

Figure 6. Bladder wall interruption. 40-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 34 weeks of pregnancy. T2-weighted HASTE MR image of the pelvis in the sagittal plane shows placenta previa with anterior bladder wall interruption (arrowhead). Intraoperative findings confirmed severe AIP.

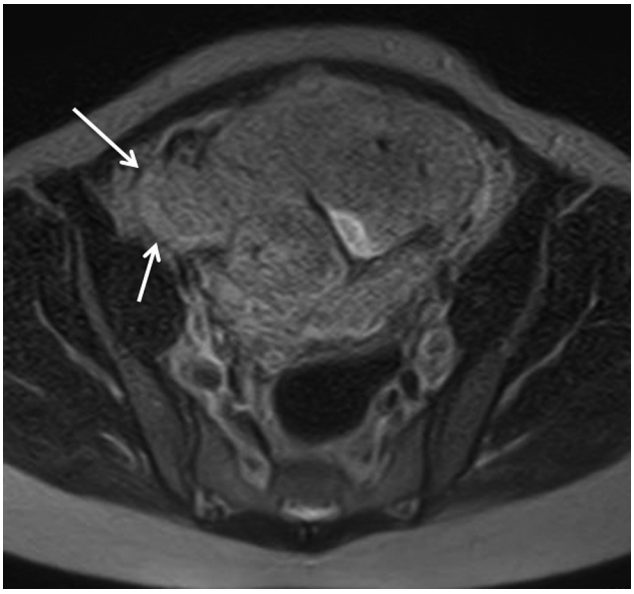

Figure 7. Focal exophytic mass. 27-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 35 weeks of pregnancy. T2-weighted HASTE MR image of the pelvis in the transverse plane shows right lateral focal exophytic mass (arrows). Intraoperative findings confirmed severe AIP.

using a 1.5-Tesla unit although MRI examination performed at 3-Tesla appears to be safe during pregnancy [33—36].

The end of the Tower of Babel

The International Society for Abnormally Invasive Placenta (www.IS-AIP.org; formerly the EW-AIP) is an international

Figure 8. Abnormal vascularisation of the placental bed. 39-year-old woman with suspected abnormally invasive placenta (AIP) who had MR imaging of the pelvis at 30 weeks of pregnancy. T2-weighted BLADE MR image of the pelvis in the sagittal plane shows abnormal vascularization of the placental bed (arrows). Intraoperative findings confirmed severe AIP.

society, currently consisting of obstetricians, gynecologists, radiologists, pathologists, anesthesiologists and basic science researchers from eleven European countries. The aim of the group is to advance diagnosis and treatment and to promote research and knowledge on AIP. To improve comparability of future studies, to increase diagnostic capabilities and to facilitate international collaboration, the IS-AIP here proposes standardized definitions of AIP-MRI descriptors.

Studies reporting the use of MRI for antenatal diagnosis of AIP were analyzed [25,30,31,37—46]. The exact wording used for MRI descriptors of AIP was tabulated. These descriptions were grouped according to MRI sequences (T1- or T2-weighted images). The different terms used were examined, grouped according to sign and then replaced by a single, unambiguous, straightforward descriptor. These descriptors were discussed by a panel of experts present at the 9th EW-AIP meeting in Brussels in November 2015, who consensually agreed upon. During this meeting, and in further discussions among all EW-AIP members, importance was placed on unambiguously defining each sign, irrespective of opinions regarding the diagnostic values of each descriptor. These unified descriptors were augmented by typical MR images that all experts agreed upon their characteristic features.

Thirteen papers were examined for wording used to describe AIP signs. These were extracted and grouped by MRI sequences, and synonymous or identical terms unified under a common heading. Five common descriptors for signs seen on T2-weighted MR images and four for T2-weighted and T1-weighted MR sequences were agreed by the expert

group, meant to unambiguously describe the sign or finding (IS-AIP suggestion). The occurrence of each descriptor is listed in Table 1. Compound signs (e.g. ''myometrial thinning < 1 mm AND focal disruption of myometrium'') were grouped in the same descriptors. MR imaging examples of the unified descriptors are provided in Figs. 1 to 8.

We assume that these MRI descriptors for AIP will be useful for clinical use, education, teaching and future research projects. Using a uniform terminology for AIP should become the first step of a standardized MRI report. In addition to using a uniform terminology, exact description of placental location and the placental portion suspicious for abnormal invasion (the location of AIP) should be considered a standard requirement for describing affected cases.

Conclusion

Maternal mortality and morbidity associated with AIP are reduced when women with this condition deliver in a tertiary referral center with an experienced multidisciplinary team [1,8,9,47]. Referral to such a team depends on the prenatal diagnosis of AIP by the primary healthcare providers. By clearly defining the AIP descriptors on MRI we provide strong support to this referral process. The rarity of AIP needs close collaboration between centers both nationally and internationally. Ensuring that all investigators are reporting the same MRI findings when referring to a specific sign will improve homogeneity of data collection making results more valid. Based on these new descriptors we are currently collecting evidence and expert opinions for the predictive value of these signs, aiming to develop guidelines for diagnosing and managing AIP.

Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

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Ethical statement

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.diii.2019.02.004.

Disclosure of interest

The authors declare that they have no competing interest.

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