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Intrapartum and perinatal results associated with different degrees of staining of meconium stained amniotic fluid

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ABSTRACT

Objective: To determine the intrapartum and perinatal results associated with different degrees of staining of meconium stained amniotic fluid (MSAF).
Study design: In a retrospective cohort study of all singleton deliveries over a period of one year (2015) in a tertiary hospital, we compared different degrees of MSAF (yellow, green and thick) to clear amniotic fluids, and analysed in each group maternal, intrapartum and neonatal variables as well as umbilical cord blood gas analysis.
Results: Of the 3590 deliveries included, 503 (14%) had MSAF. The incidence of MSAF rises with gestational age at delivery, reaching 20.7% in gestations above 41 weeks compared to 4.3% below 37 weeks. As the amniotic fluid staining progresses we found a higher proportion of intrapartum fevers ($p < 0.001$), pathological fetal heart rate patterns ($p < 0.05$), operative vaginal deliveries and cesarean sections ($p < 0.001$), as well as the need for advanced neonatal resuscitation ($p < 0.001$). There was also a correlation between MSAF and low Apgar scores at five minutes ($p < 0.001$) and fetal-neonatal mortality ($p < 0.001$) but there was not a higher proportion of neonatal intensive care admissions ($p > 0.05$). We have observed a similar distribution of umbilical artery pH ranges in all groups ($p > 0.05$).
Conclusions: MSAF was associated with an increase in the rate of pathological fetal heart rate patterns, intrapartum fevers, operative vaginal and cesarean section deliveries, need for neonatal resuscitation, low Apgar scores and higher fetal-neonatal mortality. Moreover, we found that the risks increase as the staining and consistency of the amniotic fluid evolves so it should alert the obstetrician and paediatrician to the potential adverse outcomes.

Introduction

The meconium stained amniotic fluid (MSAF) is observed in 12–16% of deliveries [1]. The intrauterine presence of MSAF may simply represent the normal gastrointestinal maturation or may indicate an acute or chronic hypoxic event [2] thereby making it a warning sign of fetal compromise. Its presence is associated with an increase in perinatal morbidity and mortality. Higher rates of stillbirths, low Apgar scores and hypoxic ischemic encephalopathy have been associated with MSAF [3,4].

It is known that intrapartum and perinatal complications increase as the staining and consistency of amniotic fluid increases [5]. This way, yellow amniotic fluids are associated with fewer complications and less morbidity than green ones, and these, in turn, less than thick amniotic fluids, which leads us to think that they could be different entities.

The umbilical cord blood gas analysis is an indicator of fetal hypoxic damage and may provide important information about the past, the present and possibly the future condition of the newborn [6].

Therefore, in this study we intend to compare the intrapartum and perinatal results as well as the umbilical cord blood gas analysis of the different types of MSAF versus the clear ones.

Materials and methods

A retrospective cohort study was carried out in the University Hospital Complex of Vigo, a university-affiliated tertiary hospital, where we analysed all deliveries over a period of one year. The study included all singleton deliveries after 24 weeks' gestation during the year 2015.

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MSAF were classified into three groups: yellow (meconium that lightly stains the amniotic fluid), green (dark green moderate staining of the amniotic fluid) and thick (opaque and thick meconium, also called "pea soup meconium"). Blood-stained amniotic fluids (BSAF) were considered as a different group, we did not include it in the MSAF group because they are physiopathologically different. We compared parturients with clear amniotic fluid (CAF) to those with MSAF and BSAF. The staining of amniotic fluid was assessed visually at the time of rupture of membranes and the obstetrician or midwife who attends the delivery determined the grade of staining. We chose this classification because it is simple and unifies criteria visually.

Background medical data of pregnant woman and newborn were collected retrospectively from our electronic health records and partograms. The Ethical Review Board of the University Hospital Complex of Vigo approved the data collection for the study. The following variables were analysed: maternal variables (age, parity and gestational age), intrapartum variables (onset of labour, amniotic fluid colour, category of intrapartum fetal heart rate –FHR-, intrapartum fever and mode of delivery), umbilical (arterial and venous) cord blood gas analysis (pH, pO_2, pCO_2, HCO_3 and base excess) and neonatal variables (sex, birth weight, Apgar score, neonatal intensive care admission and need for neonatal resuscitation).

The gestational age at delivery was established by the last menstrual period and verified by ultrasonographic gestational age measurement, if the due date determined by menstrual period differed from that calculated by ultrasounds (>7 days in the first trimester, >14 days in the second trimester and >21 days in the third trimester) then the due date obtained by ultrasound was used to define gestational age. The amniotic fluid colour was diagnosed clinically during delivery by the obstetrician or midwife. Electronic continuous FHR monitoring was used in all parturients from the beginning of labour or induction to delivery. The FHR category was established according to the National Institute of Child Health and Human Development [7]. Intrapartum fever was defined as at least one axillary temperature measurement of ≥37.8 °C. In our department, the umbilical cord blood gas analysis is done routinely in all deliveries and a paediatrician is always present in deliveries with MSAF or BSAF. Apgar score of the newborn was assessed at 1 and 5 min. Resuscitation was considered according to the need determined by Apgar scoring by the paediatrician and was divided in superficial (aspiration –grade I-, supplementary O2 –grade II-) and advanced (CPAP –grade III-, intubation –grade IV-, chest compression with positive pressure ventilation –grade V-). In our hospital aspiration (oro-pharyngeal suction) was not systematically done in all infants born through MSAF, since evidence did not find a benefit of intrapartum aspiration of the upper airways to reduce the risk of meconium aspiration syndrome [8]. The meconium aspiration syndrome is defined as respiratory distress in newborn infants born through MSAF whose symptoms cannot be otherwise explained [9], the diagnosis was made by clinical examination and/or Chest X-Ray.

The statistical analysis was performed using the Statistical Package for the Social Sciences 19.0 (SPSS Inc., Chicago, IL, USA) and the statistical software package of R version 3.3.2. The qualitative variables were analysed by the Pearson chi-square test and the estimation of p value by Monte Carlo method with R software to obtain accurate results when the data does not have any of the underlying assumptions necessary to obtain reliable results with the Pearson chi-square test. The quantitative variables were analysed by the Kruskal-Wallis test. Statistical significance was considered at p value of less than 0.05.

Table 1
Study groups (amniotic fluid classification).

	n	%
CAF	3060	*85.2*
MSAF	503	*14.0*
Yelow	208	*41.3*
Green	277	*55.1*
Thick	18	*3.6*
BSAF	27	*0.8*
TOTAL	3590	*100.0*

CAF: clear amniotic fluid; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid.

Results

A total of 3590 deliveries were included in this study. Of these, 503 had MSAF (14%): 208 yellow (41.3%), 277 green (55.1%) and 18 thick (3.6%). The BSAF amounted to 0.8% (n = 27) [Table 1]. The mean maternal age of the study group was 33.2 (range: 15–51), we have not found relationship between maternal age and amniotic fluid classification.

We found a higher incidence of MSAF as the weeks of gestation increased, being significant ($p < 0.001$) when we studied it at intervals: ≤37 weeks (4.3% of MSAF), 37–40 weeks (13.2%) and ≥41 (20.7%) [Table 2].

We observed a higher significant proportion of MSAF in primiparous than in multiparous women (64.8% vs. 35.2%) ($p < 0.001$) [Table 2].

When we analysed the onset of labour, no differences were found between the inductions and the spontaneous onset deliveries (52.2% of MSAF in inductions vs. 47.8% in spontaneous) (p 0.069) [Table 3]. The amniotic fluids from all planned cesarean sections (n = 182) were clear.

There were a higher proportion of intrapartum fevers in MSAF vs. CAF (20.5% vs. 12.4%) ($p < 0.001$). In addition, the proportion increased as the colour of the amniotic fluid progresses (12.4% in CAF, 17.3% in yellow, 20.2% in green and 61.1% in the thick ones). BSAF presented fever in 11.1% of cases (similar to CAF) [Table 4].

Table 2
Maternal variables (Gestational age & Parity) by amniotic fluid classification.

	Gestational age*						Parity**			
	<37 w	%	37–40 w	%	≥41 w	%	Primiparous	%	Multiparous	%
CAF	217	*93.1*	2328	*86.1*	515	*79.0*	1673	*83.0*	1387	*88.1*
MSAF	10	*4.3*	358	*13.2*	135	*20.7*	326	*16.2*	177	*11.2*
Yelow	2	*0.9*	144	*5.3*	62	*9.5*	124	*6.2*	84	*5.3*
Green	8	*3.4*	202	*7.5*	67	*10.3*	187	*9.3*	90	*5.7*
Thick	0	*0.0*	12	*0.4*	6	*0.9*	15	*0.7*	3	*0.2*
BSAF	6	*2.6*	19	*0.7*	2	*0.3*	16	*0.8*	11	*0.7*
TOTAL	233	*100*	2705	*100*	652	*100*	2015	*100*	1575	*100*

CAF: clear amniotic fluid; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid.
* p value 0.000 (Monte Carlo method), considering MSAF as a unique group and as three different groups.
** p value 0.000 (Pearson Chi-Square Test), considering MSAF as a unique group and as three different groups.

Although we know that there is an association between the use of epidural analgesia and the presence of intrapartum fever, when we analysed the use of epidural and the staining of amniotic fluid we did not find differences: the percentages of the different MSAF categories were similar in patients with and without epidural (p 0.930).

The vast majority of MSAF (78.5%) were vaginal deliveries. We found an increased risk for operative vaginal delivery and cesarean section in the presence of MSAF ($p < 0.001$). It was observed that the cesarean rate increased with the degree of staining: 16.8% of caesarean sections in yellow liquids, 22.7% in green and 55.6% when it was thick ($p < 0.001$) [Table 4].

We analysed the FHR intrapartum pattern of the patients with MSAF and BSAF and we observed less categories I FHR patterns and more categories II and III as the colour of the MSAF fluid progressed (p 0.021) [Table 5].

Regarding neonatal outcomes, no differences were observed in the analysis of the different colours of amniotic fluid at different umbilical artery pH ranges (pH <7.00, 7.00–7.09; 7.09–7.19 and ≥7.20), all groups presented a similar distribution (p 0.218). In this analysis we lost 241 cases where we did not have information about the umbilical artery pH [Table 6]. The values of the umbilical cord blood gas analysis in all groups are shown in Table 7.

The presence of MSAF was associated with a higher proportion of Apgar scores <7 at the fifth minute ($p < 0.001$) but not in the first minute (p 0.061) [Table 8]. It was also associated with the need for neonatal resuscitation ($p < 0.001$) and with a more advanced neonatal resuscitation (grades III, IV and V) ($p < 0.001$). A greater need for advanced neonatal resuscitation was found as the amniotic fluid staining progressed (2.7% in CAF, 5.8% in yellow, 6.9% in green and 22.2% in thick ones) [Table 9].

There was not a higher proportion of neonatal intensive care admissions in MSAF cases compared to clear ones (9.9% in MSAF vs. 12.3% in CAF) (p 0.260) [Table 8]. The main indication for admission of neonates with MSAF was respiratory distress (63%).

We have not found a relationship between birthweight and amniotic fluid classification, the mean birthweight was 3216.4 (range: 420–4910).

There was an association between amniotic fluid colour and fetal-neonatal mortality ($p < 0.001$). Mortality in MSAF was 1% compared to 0.1% in CAF [Table 9]. In our study 3 neonates presented meconium aspiration syndrome (2 in green fluids and 1 in thick fluids), causing death in 2 of them.

Table 3
Onset of labour (without planned cesarean section) by amniotic fluid classification.

	Onset of labour					
	Spontaneous	%	Induction	%	TOTAL	%
CAF	1488	*51.7*	1392	*48.3*	2880	*100*
MSAF	240	*47.8*	262	*52.2*	502	*100*
Yellow	92	*44.4*	115	*55.6*	207	*100*
Green	140	*50.5*	137	*49.5*	277	*100*
Thick	8	*44.4*	10	*55.6*	18	*100*
BSAF	9	*34.6*	17	*65.4*	26	*100*
TOTAL	1737	*51.0*	1671	*49.0*	3408[a]	*100*

CAF: clear amniotic fluid; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid.
p value 0.126 (Pearson Chi-Square Test) when in the statistical analysis MASF is considered as three different groups.
p value 0.069 (Pearson Chi-Square Test) when in the statistical analysis MASF is considered as a unique group.
[a] Planned cesarean sections were excluded (182).

Table 5
FHR intrapartum category in MSAF & BSAF.

	FHR							
	I	%	II	%	III	%	TOTAL	%
MSAF	314	*62.4*	176	*35.0*	13	*2.6*	503	*100*
Yellow	149	*71.6*	56	*26.9*	3	*1.4*	208	*100*
Green	157	*56.7*	111	*40.1*	9	*3.2*	277	*100*
Thick	8	*44.4*	9	*50.0*	1	*5.6*	18	*100*
BSAF	15	*55.6*	11	*40.7*	1	*3.7*	27	*100*
TOTAL	329	*62.1*	187	*35.3*	14	*2.6*	530	*100*

FHR: fetal heart rate; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid
p value 0.021 (Pearson Chi-Square Test) when in the statistical analysis MASF is considered as three different groups.
p value 0.757 (Pearson Chi-Square Test) when in the statistical analysis MASF is considered as a unique group

Table 6
pH ranges in umbilical artery by amniotic fluid classification.

	pH							
	<7.00	%	7.00–7.09	%	7.10–7.19	%	≥7.20	%
CAF	15	*83.3*	88	*85.4*	563	*87.6*	2192	*84.8*
MSAF	3	*16.7*	12	*11.7*	79	*12.3*	373	*14.4*
Yellow	1	*5.6*	3	*2.9*	33	*5.1*	157	*6.1*
Green	2	*11.1*	9	*8.7*	42	*6.5*	206	*8.0*
Thick	0	*0.0*	0	*0.0*	4	*0.6*	10	*0.4*
BSAF	0	*0.0*	3	*2.9*	1	*0.2*	20	*0.8*
TOTAL	18	*100*	103	*100*	643	*100*	2585	*100*

CAF: clear amniotic fluid; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid.
p value 0.2186 (Monte Carlo method) when in the statistical analysis MASF is considered as three different groups.
p value 0.0613 (Monte Carlo method) when in the statistical analysis MASF is considered as a unique group.

Table 4
Intrapartum variables (Intrapartum fever & Mode of delivery) by amniotic fluid classification.

	Intrapartum fever*				Mode of delivery**							
	No	%	Yes	%	Normal vaginal	%	Operative vaginal	%	Cesarean section	%	TOTAL	%
CAF	2681	*87.6*	379	*12.4*	1724	*56.3*	764	*25.0*	572	*18.7*	3060	*100*
MSAF	400	*79.5*	103	*20.5*	231	*45.9*	164	*32.6*	108	*21.5*	503	*100*
Yellow	172	*82.7*	36	*17.3*	116	*55.8*	57	*27.4*	35	*16.8*	208	*100*
Green	221	*79.8*	56	*20.2*	113	*40.8*	101	*36.5*	63	*22.7*	277	*100*
Thick	7	*38.9*	11	*61.1*	2	*11.1*	6	*33.3*	10	*55.6*	18	*100*
BSAF	24	*88.9*	3	*11.1*	7	*25.9*	7	*25.9*	13	*48.1*	27	*100*
TOTAL	3105	*86.5*	485	*13.5*	1962	*54.7*	935	*26.0*	693	*19.3*	3590	*100*

CAF: clear amniotic fluid; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid.
* p value 0.000 (Monte Carlo method) when in the statistical analysis MASF is considered as three different groups. p value 0.000 (Pearson Chi-Square Test) when in the statistical analysis MASF is considered as a unique group.
** p value 0.000 (Pearson Chi-Square Test), considering MSAF as a unique group and as three different groups.

Table 7
Cord blood gas analysis, expressed in mean (standard deviation).

	Arterial				Venous			
	pH	pCO_2	HCO_3	BE	pH	pCO_2	HCO_3	BE
CAF	7.24 (0.074)	51.80 (10.009)	17.93 (2.299)	−5.92 (2.817)	7.30 (0.069)	41,59 (8.098)	18.30 (2.224)	−6.08 (2.545)
MSAF	7.25 (0.069)	50.95 (9.704)	17.70 (2.317)	−6.07 (2.599)	7.28 (0.063)	42.50 (7.693)	17,84 (2.176)	−6.47 (2.406)
Yellow	7.24 (0,069)	50.31 (10.104)	17.89 (2.166)	−5.93 (2.510)	7.29 (0.064)	42.32 (8.107)	17.99 (2.039)	−6.34 (2.317)
Green	7.23 (0.071)	51.49 (9.575)	17.61 (2.430)	−6.14 (2.654)	7.28 (0.064)	42.76 (7.538)	17.77 (2.266)	−6.52 (2.456)
Thick	7.23 (0.040)	49.79 (4.250)	16.69 (2.027)	−6.84 (2.768)	7.27 (0.052)	41.79 (3.867)	16.92 (2.314)	−7.14 (2.750)
BSAF	7.24 (0.080)	52.17 (8.791)	18.08 (2.814)	−5.63 (3.363)	7.29 (0.060)	43.21 (5.509)	18.39 (2.384)	−5.70 (2.868)
p value (Kruskal-Wallis)	0.512	0.000	0.059	0.268	0.000	0.040	0.000	0.008

BE: Base excess.

Table 8
Neonatal variables (Apgar scores & Neonatal care admission) by amniotic fluid classification.

	Apgar 1 min*				Apgar 5 min**				Neonatal care admission***				TOTAL	%
	<7	%	≥ 7	%	<7	%	≥7	%	No	%	Yes	%		
CAF	27	*0.9*	3033	*99.1*	3	*0.1*	3057	*99.9*	2685	*87.7*	375	*12.3*	3060	*100*
MSAF	12	*2.4*	491	*97.6*	5	*1.0*	498	*99.0*	453	*90.1*	50	*9.9*	503	*100*
Yellow	3	*1.4*	205	*98.6*	0	*0.0*	208	*100.0*	193	*92.8*	15	*7.2*	208	*100*
Green	6	*2.2*	271	*97.8*	2	*0.7*	275	*99.3*	246	*88.8*	31	*11.2*	277	*100*
Thick	3	*16.7*	15	*83.3*	3	*16.7*	15	*83.3*	14	*77.8*	4	*22.2*	18	*100*
BSAF	2	*7.4*	25	*92.6*	2	*7.4*	25	*92.6*	25	*92.6*	2	*7.4*	27	*100*
TOTAL	41	*1.1*	3549	*98.9*	10	*0.3*	3580	*99.7*	3163	*88.1*	427	*11.9*	3590	*100*

CAF: clear amniotic fluid; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid.
* p value 0.000 (Monte Carlo method) when in the statistical analysis MASF is considered as three different groups. p value 0.061 (Pearson Chi-Square Test) when in the statistical analysis MASF is considered as a unique group.
** p value 0.000 (Monte Carlo method) when in the statistical analysis MASF is considered as a unique group and as three different groups.
*** p value 0.121 (Monte Carlo method) when in the statistical analysis MASF is considered as three different groups. p value 0.260 (Pearson Chi-Square Test) when in the statistical analysis MASF is considered as a unique group.

Table 9
Neonatal variables (Neonatal resuscitation & Mortality) by amniotic fluid classification.

	Resuscitation*						Mortality**				Total	%
	No	%	Superficial	%	Advanced	%	No	%	Yes	%		
CAF	2110	*69.0*	868	28.4	82	*2.7*	3057	*99.9*	3	*0.1*	3060	*100*
MSAF	104	*20.7*	364	72.4	35	*7.0*	498	*99.0*	5	*1.0*	503	*100*
Yellow	62	*29.8*	134	64.4	12	*5.8*	208	*100.0*	0	*0.0*	204	*100*
Green	40	*14.4*	218	78.7	19	*6.9*	275	*99.3*	2	*0.7*	281	*100*
Thick	2	*11.1*	12	66.7	4	*22.2*	15	*83.3*	3	*16.7*	18	*100*
BSAF	9	*33.3*	16	59.3	2	*7.4*	25	*92.6*	2	*7.4*	27	*100*
TOTAL	2223	*61.9*	1248	34.8	119	*3.3*	3580	*99.7*	10	*0.3*	3590	*100*

CAF: clear amniotic fluid; MSAF: meconium stained amniotic fluid; BSAF: blood stained amniotic fluid.
* p value 0.000 (Pearson Chi-Square Test), considering MSAF as a unique group and as three different groups.
** p value 0.000 (Monte Carlo method), considering MSAF as a unique group and as three different groups.

Comment

The aim of this study was to assess the association between the different degrees of amniotic fluid staining with intrapartum and neonatal outcomes. Our main findings were: (1) positive relation between the rate of MSAF and gestational age at delivery, (2) as the amniotic fluid staining progresses we have seen a higher proportion of intrapartum fevers, more pathological FHR patterns, an increased risk for operative vaginal and cesarean sections deliveries and a greater need for advanced neonatal resuscitation, (3) association between MSAF and fetal-neonatal mortality and (4) similar distribution of umbilical artery pH in all groups.

The exact etiology of MSAF remains unclear. In our study, the prevalence of MSAF was similar to previous reports. Moreover, in concordance with prior reports, we have observed that the incidence of MSAF rises with gestational age at delivery, reinforcing the theory that MSAF at term is a physiological event that may reflect the maturity of fetal gastrointestinal tract. The presence of MSAF is rare before 34 weeks of gestation and the incidence increases steadily beyond 37 weeks of gestation [10]. Factors such as placental insufficiency, maternal hypertension, preeclampsia, oligohydramnios or abuse of maternal drugs result in staining of the amniotic fluid [11]. Despite the fact that MSAF may represent a physiological event at late gestation, it was still a risk factor for neonatal complications and especially respiratory morbidity. Hiersch et al. have found that neonates exposed to MSAF, who were delivered at early term, were at increased risk for neonatal intensive care admission and neonatal adverse outcomes such as neonatal sepsis, jaundice, and low Apgar score compared with those delivered at full term [12].

The most acceptable theories to explain the passage of meconium were attributed to the response of the fetus to hypoxia or a vagal stimulation from umbilical cord compression resulting in an increased fetal peristalsis. It should be considered as a marker

for increased perinatal complications. Altshuler and Hyde [13] suggested that meconium has a vasoconstrictive effect on umbilical vessels, which may explain the increased incidence of pathological FHR so there is an increased risk for operative vaginal delivery and cesarean section, as found in our study. MSAF was also found to be associated with subclinical inflammatory processes, considering it as a risk factor of microbial infection of the amniotic cavity [14,15]. The incidence of MSAF and neonatal morbidity was shown to be higher in the presence of inflammation of placental membranes [16]. Our study found an association between the presence of MSAF and intrapartum fever, supporting the view that the presence of MSAF should be an alert of potential infection and increased neonatal morbidity.

An association of MSAF with maternal ingestion of certain drugs and herbal remedies during pregnancy has been suggested but not very investigated. Meconium passage was found to be more common in women who had recently taken castor oil (a fatty bland oil contrainticated during pregnancy but still recommended by some for labour induction, it causes rapid evacuation of bowel contents as well as uterine contractions) and herbal sustances called "sihlambezo" (widespread use in south Africa) [17]. According to Chitrakar [18], a 25 μg intravaginal misoprostol reduces meconium passage and MSAF was found more in the inductions with dinoprostone. The use of laxative or enemas, which were suggested, was not associated with meconium passage [17].

In agreement with previous reports [19], we found an increased rate of neonatal complications in the presence of MSAF: low Apgar scores, a need for advanced resuscitation and fetal-neonatal mortality. Most neonatal adverse outcomes observed, like in others reports, were related to pulmonary pathology: respiratory distress and the need for ventilator support as well as the meconium aspiration syndrome. Meconium was found to cause umbilical cord vascular necrosis and also to be toxic to fetal lung (causing obstruction of airways, chemical pneumonitis, vasoconstriction of pulmonary vessels, and inactivation of surfactant) [20]. Despite the increase in neonatal complications observed, no differences have been found in umbilical artery pH between groups, which is an objective measure of neonatal condition. Respiratory acidosis was not observed, so there were no cases of neonatal asphyxia or it was metabolically compensated at the time of its measurement.

An interesting matter is the clinical significance of the change in colour of amniotic fluid, from clear to meconium (secondary meconium), and the different prognosis between it and primary meconium (MSAF noted at the time of membranes rupture). While primary meconium seems to be more related with fetal maturation, secondary meconium is more likely to reflect intrapartum fetal distress. However, only few studies distinguished between primary and secondary meconium and supported the importance of distinction between them with respect to the increased risk for adverse outcomes in the secondary: low 5-min Apgar score, neonatal intensive care admission, umbilical artery pH < 7,1 and intrapartum cesarean section [21,22].

Another interesting question is, what is the significance of the transformation from CAF to yellow, green and finally thick fluid, and whether the outcome in these different cases of MSAF is different. Our study demonstrates that the risks increase as the colour and consistency of the amniotic fluid evolves. However, this is the first study that compares and separates the different types of MSAF. Past reports suggested that the "thickness" of meconium had a direct bearing on the neonatal outcome, showing that incidence of birth asphyxia was significantly higher in thick meconium compared to thin meconium [23].

Therefore, where does MSAF come from? Recently, it has been documented that in-utero defecation occurs throughout fetal life as a physiologic function during fetal development [24]. The intestinal content in the fetus (meconium) is of a greenish colour, which results from the accumulation of the bile pigments [25]. However, as the basic theories and recent reports assert [26,27], it emerges as a clear fluid because there is a balance in the fetal circuits of swallowing, urination and respiratory tract secretion. If the balance is broken, the amniotic fluid will be stained, probably related to a biochemical change in the bilirubin oxidation system, responsible for biliverdin formation (main component that gives the greenish colour of meconium).

The limitations of our study were mainly due to its retrospective design. Perhaps certain management decisions and interventions triggered by the observation of MSAF may affect outcomes and thus bias the apparent association of MSAF with these outcomes: increased operative vaginal delivery and cesarean section may be due to the perception of caregivers that MSAF is a sign of fetal compromise, rather than an effect of the MSAF per se. Additionally, a paediatrician is always present in deliveries with MSAF and that could have biased the Apgar scores assesments. Moreover, other potential confounders for adverse pregnancy outcome, such as the rate of maternal obesity, maternal diseases, gestational diseases and toxic habits were not analysed. However, the strengths of our study lie on its large cohort and the available data regarding intrapartum and neonatal outcomes. In addition, our study represents the first study that emphasizes the importance of distinction between the different stains of the amniotic fluid due to its significance on obstetrical and neonatal outcome.

In conclusion, our study shows that the presence of MSAF is associated with an increase in the rate of pathological FHR patterns, intrapartum fevers, low Apgar scores and is associated with higher fetal-neonatal mortality. In order to reduce perinatal morbidity and mortality, the presence of MSAF requires intensive FHR monitoring and a certain clinical performance depending on the type of MSAF as we have shown that the obstetrical and perinatal complications increase with the degree of amniotic fluid staining and consistency. The fact of having lower Apgar scores and a greater need for advanced resuscitation leads to an immediate and proper pediatric assessment.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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