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ORIGINAL ARTICLE

Non-diabetic fetal macrosomia: outcomes of elective delivery versus expectant management

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Abstract

Background Macrosomia in the absence of diabetes can be associated with increased neonatal and maternal morbidity. Management is usually undertaken on a case-by-case basis.

Aims In order to inform local practice, this study aimed to evaluate the outcomes of the management of non-diabetic macrosomia in an Irish tertiary center.

Methods A retrospective observational study was performed on all women with estimated fetal weight over 4000 g after 37 weeks' gestation. Maternal demographics and obstetric and neonatal outcomes were recorded using the hospital information system. Women with diabetes, previous caesarean section, non-cephalic presentation, or any other complicating condition were excluded. Women were divided into two groups:

1. Active management: Elective delivery for macrosomia—between 38 + 0 and 40 + 6 weeks' gestation
2. Expectant management: with induction of labour offered after 41 weeks' gestation

Results There were 397 women included, 188 with active and 209 with expectant management. There was no difference in adverse neonatal outcomes, major maternal morbidity, or mode of delivery, after exclusion of pre-labor caesarean section. Women with expectant management were more likely to go into spontaneous labor (46.9 vs 1.6%, $p < 0.001$) and to have a favorable cervix at the onset of induction of labor if nulliparous (86.1 vs 70.0%, $p = 0.021$), but have higher rates of episiotomy (28.6 vs 18.2%, $p = 0.021$). With active management, nulliparas with an unfavorable cervix had increased risk of anal sphincter injury (6.5 vs 0.0%, $p = 0.007$) and postpartum hemorrhage (59.0 vs 35.5%, $p = 0.003$).

Conclusions Overall, there was no difference in major maternal or neonatal outcomes between management options for fetal macrosomia. However, inducing nulliparas with an unfavorable cervix for non-diabetic macrosomia was associated with obstetric anal sphincter injury and postpartum hemorrhage.

Keywords Induction of labor · Macrosomia · Maternal morbidity · Neonatal morbidity · Obstetric anal sphincter injury · Spontaneous labor

Introduction

Fetal macrosomia may be defined as an estimated fetal weight (EFW) greater than 4000 g diagnosed on antenatal ultrasonography [1]. Risk factors for macrosomia include diabetes, maternal obesity, and advancing maternal age [2]. Fetal macrosomia was historically associated with grand-multiparity [3]. More recently, it is seen in nulliparous mothers, for whom labor and delivery already have a more challenging course. This is due to a variety of reasons including older maternal age at first pregnancy, increasing

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incidence of obesity [4] and diabetes [5–7] and excessive maternal weight gain in pregnancy [8]. Fetal macrosomia in the absence of diabetes is associated with increased morbidity for mothers and their babies [9, 10]. Maternal morbidity includes labor dystocia, postpartum hemorrhage, pelvic floor morbidity, and obstetric anal sphincter injury [2, 9]. Neonatal morbidity includes shoulder dystocia, brachial plexus injury, birth fractures, and hypoxic-ischemic encephalopathy [2, 9].

In Ireland, birth weights have been stable over the past three decades [11]. However, ultrasound diagnosis of macrosomia during pregnancy may be more common and creates a clinical dilemma as consensus on best management is lacking. Even with extensive training and high-quality imaging, sonographic estimation of fetal weight at term is prone to be inaccurate [12, 13]. Some national consensus groups recommend avoiding screening for macrosomia in the third trimester, as it can increase intervention without improving outcome [14].

While benefit of induction of labor in diabetic macrosomia has been shown to reduce shoulder dystocia and perinatal morbidity [15, 16], there is conflicting evidence on the optimum strategy for delivery of macrosomic babies in the absence of diabetes. Several studies including a 2016 meta-analysis found that a strategy of management made no difference to mode of delivery [17–19]. Other observational studies have reported conflicting rates of caesarean section in women induced for macrosomia [20] but no significant difference in operative vaginal delivery (OVD). There has been conflicting evidence on neonatal outcomes with a 2016 Cochrane review reporting shoulder dystocia and fracture being lower with early induction [18]. Another large meta-analysis in 2016 [17] found no difference in mode of delivery or neonatal morbidity (including shoulder dystocia, intracranial hemorrhage, brachial plexus injury, or low Apgar scores) with labor induction versus expectant management. There is an absence of resounding evidence for the reduction of maternal morbidity with either elective delivery or expectant management. Some studies have shown a slightly higher risk of obstetric anal sphincter injuries (OASIs) with elective induction [18] and others found no difference [17]. Thus, the evidence does not robustly support either strategy, making it challenging to devise international consensus clinical guidelines or local practice protocols.

With the challenges of managing this condition in the absence of conclusive evidence, counseling women with accurate local data on risk and morbidity can be empowering to both the woman and her obstetrician. In this study, the aim was to analyze Irish outcomes of elective delivery compared to expectant management for fetal macrosomia in the absence of maternal diabetes.

Materials and methods

A retrospective observational study was performed on all women diagnosed with fetal macrosomia on antenatal ultrasound over a 3-year period (January 1st, 2017, to 31st December 2019). This study was performed at a large tertiary referral university teaching maternity centre; the Coombe Women and Infants University Hospital in Dublin, Ireland. Macrosomia was defined as an estimated fetal weight (EFW) of greater than 4000 g. Cases of EFW over 4000g were identified on the electronic hospital ultrasound imaging system. Although this center does not perform routine third trimester growth ultrasound, formal biometry is requested on any pregnant patient if their obstetrician or midwife is concerned about fetal growth. Departmental ultrasounds are performed by experienced sonographers or consultants in maternal fetal medicine and recorded on the electronic imaging system.

All women with a singleton pregnancy, cephalic presentation with an antenatal ultrasound diagnosis of macrosomia (EFW over 4000 g) were included. Women with pre-existing and gestational diabetes mellitus were excluded and verified by a negative oral glucose tolerance test. Other exclusion criteria were factors that strongly influenced timing and mode of delivery including previous caesarean section, non-cephalic presentation, or any indication for delivery prior to term for reasons other than macrosomia. Decisions around active versus expectant management are usually made in this unit between 38 and 39 weeks' gestation, following discussion between the woman and her obstetric team. Cases with onset of spontaneous labor prior to this discussion were excluded.

Patients were divided into two groups according to the management they received:

1. Elective delivery for macrosomia—active management (AM)
    (a) Induction of labor (IOL) between 38 + 0 and 40 + 6 weeks' gestation for macrosomia alone, in the absence of other indications for delivery
    (b) Elective caesarean section (ELSCS) for same reason
2. Expectant management (EM) anticipating spontaneous labor with IOL offered at 41 + weeks for post-maturity.

The demographic factors of each group were compared, including maternal age, parity, height, and BMI. Obstetric variables including gestation, onset of labor, and mode of delivery were collected. Indications for IOL and caesarean section were also included. Complications in the second

stage of active labor were included such as sequential-instrument operative vaginal delivery (OVD) and second stage caesarean section. Given its association with long-term pelvic floor morbidity [2], prolonged second stage was also included, defined as more than 2 h in multiparous women or 3 h in primiparous women [21]. Rates of postpartum hemorrhage (PPH) were recorded where PPH was classified as estimated blood loss over 500 ml [22]. Obstetric anal sphincter injuries (OASIs) were recorded using Sultan's classification system [23], recommended by the Royal College of Obstetricians and Gynaecologists [24]. When indicated, episiotomies were performed using the right mediolateral technique. Method of induction of labor was included. In this center, where a woman's Bishop score was deemed adequate not to require prostaglandin (typically score of seven or more), she moves directly to artificial rupture of membranes (ARM) and oxytocin induction on the labor and delivery suite. Where cervical ripening is required, vaginal prostaglandin is administered on the antenatal ward. The first-line prostaglandin formulation for cervical ripening in this center is administration of dinoprostone vaginal pessary 10 mg for a 24-h period, with prostaglandin gel as second-line prostaglandin if required. Neonatal outcomes were compared between groups including rates of shoulder dystocia (clinically diagnosed at delivery with need for maneuvers to treat), low Apgar scores (Apgar score less than 7 at 5 min), admission to the neonatal intensive care unit (NICU), length of NICU stay, and a composite measure of neonatal morbidity including brachial plexus injury, humeral fracture, brachial plexus injury, or hypoxic ischemic encephalopathy.

Full data collection was then performed for each identified case using the hospital IT system. Data was reported using study ID numbers, with the IT manager holding the code for pseudo-anonymization. All patient data was retained on hospital devices with double password-protected encryption, in line with GDPR. Once the dataset was complete, the code for pseudo-anonymization was deleted, leaving the data anonymous. Approval for this review of local practice and outcomes was granted by the institution's clinical governance board.

All demographic details, background variables, and obstetric maternal and neonatal outcomes were compared between two management groups. Pre-labor caesarean sections were then excluded, and all patients who had a trial of labor (IOL or spontaneous labor) were then analyzed by management group. Categorical variables were reported in frequencies and proportions for each group and were analyzed using chi-squared testing. For dichotomous categorical variables, relative risk and odds ratios were calculated with 95% confidence intervals. Continuous variables were reported by mean value with standard deviation and minimum and maximum values and were compared using the independent *t* test. Subgroup analysis by parity and gestation at active management was performed for all outcomes, comparing outcomes for AM at 38, 39, and 40 weeks to expectant management. Analysis by induction method was also performed, as surrogate marker or cervical favorability at commencement of IOL. Data were analyzed using SPSS Version 24.0 (Armonk, NY; IBM Corp) software system.

Results

A total of 397 women were included in this study, 188 women with active, and 209 with expectant management (Table 1). Women in the AM group were older (33.0 vs 31.7 years, $p=0.008$) but the groups were otherwise similar for parity, body mass index, and maternal height. The number of ongoing pregnancies is shown in Fig. 1 with women in the AM group delivered significantly earlier than EM (Chi sq 177.7, df31, $p<0.0001$), including both nulliparas (chi-sq 123.8, df28, $p<0.0001$) and multiparas (chi-sq 73.5, df29, $p<0.0001$). EM had significantly higher chance of spontaneous labor (46.9% vs 1.5%, $p<0.001$) with 34.2% of nulliparas and 63.0% of multiparas going into spontaneous labor (Table 1).

Neonatal outcomes

Birth weights were similar between both groups, for both nulliparous and multiparous women (Table 1). There was no significant difference in rate of NICU admission (6.9% vs 5.3%, $p=0.505$) or NICU length of stay (1.67 vs 1.72 days, $p=0.969$) between management groups. Rates of shoulder dystocia (1.6% vs 1.4%, $p=0.870$) and neonatal morbidity (1.6% vs 2.4%) were also comparable between groups (Table 1).

Maternal outcomes

Pre-labor caesarean section was more common in the active management group. Examining women who had a trial of labor (Table 2), there was no significant difference in mode of delivery across management groups for nulliparous or multiparous women. EM had shorter induction process than AM, particularly in nulliparous women who had greater chance of not requiring prostaglandin for IOL (30.0% vs 13.9%, $p=0.021$). The duration of labor was shorter in the EM group with multiparous women having a significantly longer first (5.08 vs 3.10 h, $p<0.001$) and second stage (00.38 vs 00.25 h, $p=0.005$). Second-stage morbidity was similar in both management groups, with similar rates of second stage caesarean Sect. (6.7% vs 6.5%, $p=0.618$), sequential OVD (1.2% vs 1.5%, $p=0.522$), and conversion from OVD to caesarean Sect. (0.6% vs 2.0%, $p=0.253$). Prolonged second stage was slightly increased with AM, but this was not

Table 1 Outcomes of active versus expectant management of non-diabetic macrosomia

	Active management						**Expectant management**						***P* value**		
	Total		**Nulliparous**		**Multiparous**		**Total**		**Nulliparous**		**Multiparous**		**Total**	**Nullip**	**Multip**
	%	***n***	%	***n***	%	***n***	%	***n***	%	***n***	%	***n***			
Total *n*		188		92		96		209		117		92		0.158	0.161
Maternal demographics															
Age (years, mean, at booking)	33.0		32.1		33.9		31.7		30.7		33.0		**0.008**	0.689	0.966
BMI	27.5		26.9		28.1		27.1		26.8		27.5		0.470	0.157	0.748
Height (cm)	166.4		165.9		166.8		167.5		167.2		170.0		0.283	0.68	0.508
Mean gestation at delivery (days)	39 + 5 39.706 (39 + 5)		39.649 (39 + 5)		39.760 (39 + 5)		40.6		40.969 (41 + 0)		40.661 (40 + 6)				
Pathway to delivery															
Spontaneous	1.6	3	1.1	1	2.1	2	46.9	98	34.2	34.2	63.0	58	**< 0.001**	**< 0.001**	**< 0.001**
Induction	86.2	162	78.2	72	93.7	90	48.3	101	59.8	59.8	33.7	31	**< 0.001**	**0.005**	**< 0.001**
Pre-labor CS	12.2	23	20.7	19	4.2	4	4.8	10	6.0	6.0	3.3	3	**0.007**	**0.001**	0.746
Delivery outcomes															
PPH (> 500 ml)	31.4	59	42.4	39	20.1	20	26.3	55	36.8	43	13.0	12	0.263	0.412	0.192
Neonatal outcomes															
Birth weight (centile, mean g)	95th	4138 g	93rd	4062 g	96th	4210	87th	4082	84th	4027	90th	4152	0.969	0.913	0.716
NICU admission	6.9	13	10.9	10	3.1	3	11	5.3	6.8	8	3.3	3	0.505	0.295	0.938
NICU length of stay (average, days)	1.67		1.93		0.9		1.72			1.81		1.5	0.969	0.339	0.275
Shoulder dystocia	1.6	3	1.1	1	2.1	2	3	1.4	2.6	3	0.0	0	0.870	0.436	0.163
Neonatal morbidity	1.6	3	3.3	3	0.0	0	5	2.4	3.4	4	1.1	1	0.572	0.968	0.304

N number of patients, *BMI* body mass index, *cm* centimeters, *CS* caesarean section, *PPH* postpartum hemorrhage, *G* grams, *NICU* neonatal intensive care unit

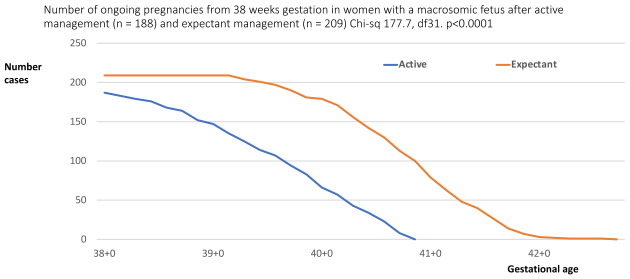

Fig. 1 Number of ongoing pregnancies from 38 weeks' gestation in women with a macrosomic fetus after active management ($n=188$) and expectant management ($n=209$)

statistically significant (7.9% vs 4.5%, $p=0.094$). There was no significant difference in post-partum hemorrhage between management groups overall (31.4% vs 26.3%, $p=0.263$) or amongst those with a trial of labor (26.1% vs 25.1%, $p=0.828$, Table 2). Overall, episiotomies were significantly less likely with AM rather than EM (18.2% vs 28.6%, $p=0.021$), which may be linked with the trend towards operative vaginal delivery in the EM group. There was no significant difference in obstetric anal sphincter injuries (OASIs, 2.4% vs 0.5%, $p=0.120$) in the overall population. Subgroup analysis comparing AM at 38, 39, and 40 weeks to expectant

Table 2 Outcomes for women with a trial of labor (excluding pre-labor caesarean section)

	Active management						**Expectant management**						***P* value**		
	Total ($n=165$)		**Nulliparous ($n=73$)**		**Multiparous ($n=92$)**		**Total ($n=199$)**		**Nulliparous ($n=110$)**		**Multiparous ($n=89$)**		**Total**	**Nullip**	**Multip**
	%	***n***	%	***n***	%	***n***	%	***n***	%	***n***	%	***n***			
Mode of Delivery															
SVD	58.2	96	26.0	19	83.7	77	55.8	111	33.0	33	87.6	78	0.646	0.314	0.456
OVD	18.8	31	34.2	25	6.5	6	23.1	46	37.3	41	5.6	5	0.318	0.670	0.800
Kiwi	10.9	18	17.8	13	5.4	5	13.1	26	20.9	23	3.4	3	0.522	0.606	0.514
Forceps	6.7	11	13.7	10	1.1	1	8.5	17	14.5	16	1.1	1	0.522	0.880	1.000
Sequential	1.2	2	2.7	2	0.0	0	1.5	3	1.8	2	1.1	1	0.522	0.683	0.315
Conversion to CS	0.6	1	1.7	1	0.0	0	2.0	4	1.8	2	1.1	1	0.253	0.960	0.315
CS	23.0	38	39.7	29	9.8	9	21.1	42	32.7	36	6.7	6	0.663	0.334	0.450
Duration of labor (hours)															
1st stage	6.00		7.24		5.08		5.07		7.01		3.10		0.124	0.744	**< 0.001**
2nd stage	1.05		1.48		0.38		1.03		1.39		0.25		0.151	0.104	**0.005**
3rd stage	0.09		0.07		0.10		0.09		0.08		0.12		0.666	0.810	0.226
Total labor	7.24		9.08		6.03		6.50		9.05		4.03		0.510	0.579	**< 0.001**
Prolonged second stage	7.9	13	13.7	10	3.3	3	4.5	9	6.5	7	2.2	2	0.094	0.100	0.677
Second stage CS	6.7	11	11.0	8	3.3	3	6.5	13	10.9	12	1.1		0.618	0.982	0.317
PPH	26.1	43	35.6	26	18.5	17	25.1	50	35.5	39	12.4	11	0.828	0.989	0.258
Perineal injury															
Episiotomy	18.2	30	31.5	23	7.6	7	28.6	57	42.7	47	11.1	10	**0.021**	0.128	0.419
OASIs	2.4	4	5.5	4	0.0	0	0.5	1	0	0	1.1	1	0.120	**0.013**	0.315
Method of IOL															
No prostaglandin	32.1	52	*13.9*	10	*45.6*	41	38.6	39	*30.0*	21	*58.6*	18	0.282	**0.021**	0.214
Prostaglandin	67.9	110	*86.1*	62	*53.3*	48	61.4	62	*70.0*	49	*41.9*	13	0.282	**0.021**	0.276
Neonatal outcomes															
Birth weight (g)	4126		4039		4102		4071		4013		4142		0.725	0.574	0.764
NICU admission	5.5	9	9.6	7	2.2	2	4.5	9	7.3	8	7.3	1	0.662	0.580	0.564
NICU length of stay (days)	1.94		2.32		0.8		1.77		1.81		1.4		0.207	0.125	0.092
Shoulder dystocia	1.8	3	1.4	1	2.2	2	1.5	3	2.7	3	2.7	0	0.823	0.557	0.162
Neonatal morbidity	1.8	3	4.1	3	0.0	0	2.5	5	3.6	4	3.6	1	0.650	0.863	0.308

N number of patients, *SVD* spontaneous vaginal delivery, *OVD* operative vaginal delivery, *CS* caesarean section, *PPH* postpartum hemorrhage, *OASIs* obstetric anal sphincter injuries, *IOL* induction of labor, *G* grams, *NICU* neonatal intensive care unit

management revealed no significant differences in mode of delivery, maternal outcomes, or neonatal outcomes.

As a surrogate marker for a favorable Bishops' score, methods of induction amongst nulliparous women within AM were examined and compared to EM. Mode of delivery and neonatal outcomes were comparable in AM and EM, regardless of cervical favorability. However, there was a significant increase in risk of postpartum hemorrhage (59.0% vs 35.5%, $p=0.003$) and obstetric anal sphincter injury (6.5% vs 0.0%, $p=0.007$) in nulliparous women with an unfavorable cervix proceeding with AM.

Discussion

This study presents maternal and neonatal outcomes of non-diabetic fetal macrosomia. Of the 397 women included in this study, the majority of women had a BMI over 25 with the mean booking BMI in the overweight category for both nulliparous and multiparous women. With expectant management, spontaneous labor occurred in almost half of cases (46.9%). Women with active management were significantly less likely to go into spontaneous labor and more likely to deliver by pre-labor caesarean section.

Importantly, this study found no significant difference in adverse neonatal outcomes, with active management conferring no protective effect against neonatal injury. This is in keeping with international studies on this subject [25] including the recent NICE guidance on induction of labor in large-for-gestational-age pregnancies [26]. However, this study did observe similar birth weights in active and expectant management, despite a significant difference in gestation at delivery. We hypothesize that this may be related to the gestation at which fetal macrosomia was diagnosed, with women with an EFW over 4 kg at 38 weeks more likely to be chose active management than if diagnosed after 40 weeks.

Examining women who had a trial of labor, there was no difference in mode of delivery across management groups. This is in keeping with results of several large studies reported [18, 27] but does contradict outcomes of the ARRIVE trial amongst a low-risk nulliparous population [28]. Overall, maternal morbidity was comparable across management groups with no significant differences in the rates of post-partum hemorrhage, obstetric anal sphincter injury, or second stage morbidity (prolonged second stage, second stage caesarean section, sequential instrumental delivery, or operative vaginal delivery converted to caesarean section). However, maternal morbidity was disproportionately experienced by nulliparous women in the active management group who required prostaglandin for induction. Interestingly, all OASIs in nulliparas occurred in women having AM with an unfavorable cervix, significantly more so than with EM (6.5 vs 0.0%, $p=0.007$). This cohort also had significantly higher rates of postpartum hemorrhage (59 vs 35.5%, $p=0.003$) than their counterparts with favorable cervix or expectant management (30.0%, $p=0.089$, and 35.5%, $p=0.003$, respectively) and higher than the center's background population, where the OASI rate is 3.27% in nulliparous vaginal deliveries and overall PPH rate is 22.7% [29].

Although major differences for multiparous women were not observed in maternal morbidity between groups, the induction process and duration of labor were significantly longer for multiparas in the AM group compared to EM. In general, elective induction for macrosomia has higher rates of requirement for prostaglandin than IOL in expectant management. This amounts to longer admissions to facilitate induction of labor. With higher rates of spontaneous labor and less requirement for prostaglandin, expectant management is associated with shorter hospital to delivery intervals, as reported in several studies in both macrosomic and normally grown babies [28]. This has implications for patients, their partners, and the healthcare facility, and will impact delivery experience. Shorter hospital admissions have many advantages including lower-risk venous thromboembolism, hospital-acquired infections including the transmission of COVID-19, and cost-effectiveness implications for the service. This should all be considered when managing fetal macrosomia.

Subgroup analysis by cervical favorability (observed by Bishops score negating need for vaginal prostaglandin) did reveal trends towards higher rates of caesarean section and lower rates of vaginal delivery amongst nulliparous women, although these were non-significant. Equally, nulliparas with a favorable cervix had trends towards higher rates of spontaneous vaginal delivery and lower rates of operative vaginal delivery and caesarean section when compared with expectant management (Table 3), although again these did not achieve statistical significance. As aforementioned, nulliparous women with an unfavorable cervix proceeding with active management had significantly higher rates of postpartum hemorrhage and obstetric anal sphincter injury. This has local practice implications, allowing healthcare providers to implement maximum preventative strategies at delivery. In this center, local focus on OASI prevention care bundles [30] has been renewed for all women, but particularly those with induction for macrosomia with re-audit of outcomes after educational and training interventions amongst healthcare providers.

Final considerations for women and their obstetricians planning for delivery are the impact of the macrosomic baby on the pelvic floor and perineum. Fetal macrosomia is associated with risk of long-term pelvic floor dysfunction [31, 32], irrespective of the gestation at delivery. Pelvic floor injury is related to multi-factorial labor dynamics rather than just birth weight itself, including prolonged second stage of

Table 3 Outcomes for active management vs expected management in nulliparous women based on method of induction

	Active management ($n=72$)					Expectant management			
	Prostaglandin, ARM, oxytocin		ARM/Oxytocin alone		ActM – unfavorable vs favorable			ActM-unfavorable vs ExpM	ActM-favorable vs ExpM
	%	$n=62$	%	$n=10$	*P*	%	$n=110$	*P*	
Maternal outcomes									
Mode of delivery									
SVD	24.2	*15*	40.0	*4*	0.296	33.0	33	0.227	0.656
OVD	35.5	*22*	30.0	*3*	0.736	37.3	41	0.815	0.648
CS	40.3		30.0	*3*	0.538	32.7	36	0.319	0.862
Prolonged second stage	12.9	*8*	20.0	*2*	0.550	6.5	7	0.156	0.081
PPH	53.2	*33*	30.0	*3*	0.089	35.5	39	**0.024**	0.728
Perineal injury		*4*							
Episiotomy	33.9	*21*	20.0	*2*	0.385	42.7	47	0.258	0.164
OASIs	6.5	*4*	0.0	*0*	0.410	0	0	**0.007**	-
Neonatal outcomes									
NICU admission	9.7	*6*	10.0	*1*	0.9765	7.3	8	0.582	0.758
Shoulder dystocia	1.6	*1*	0.0	*0*	0.689	2.7	3	0.645	0.600
Neonatal morbidity	4.8	*3*	0.0	*0*	0.507	3.6	4	0.702	0.543

N number of patients, *SVD* spontaneous vaginal delivery, *OVD* operative vaginal delivery, *CS* caesarean section, *PPH* postpartum hemorrhage, *OASIs* obstetric anal sphincter injuries, *G* grams, *NICU* neonatal intensive care unit

labor and fetal malposition [33]. Each delivery option has its own implications on pelvic floor morbidity. Expectant management has higher rates of operative vaginal delivery and episiotomy. Active management has longer durations of first and second stages of labor in multiparous women and higher rates of anal sphincter injury in nulliparous women with an unfavorable cervix. As pelvic floor morbidity is a major influential factor for many women in their choice of management, these outcome trends should be included in the conversation between them and their healthcare provider.

Strengths and limitations

Although this study attempted to include all patients with an antenatal diagnosis of fetal macrosomia, the definition of estimated fetal weight > 4000 g likely led to the omission of those managed as fetal macrosomia with EFW or abdominal circumference above the 95th centile. The other missing data point was gestation at which macrosomia was diagnosed, which is likely to be an influential factor in decisions around delivery. Another limitation is the use of method of induction as a surrogate marker for cervical favorability. As bishops score is not routinely recorded, this surrogate marker proved the most reliable way of analyzing cervical favorability but is not a robust and objective assessment. Finally, pelvic floor morbidity with fetal macrosomia can only be analyzed with the short-term findings of this study.

Research implications

Where fetal macrosomia occurs, the two main concerns to women are the safe delivery of the baby and the prevention of pelvic floor and perineal trauma. Fetal macrosomia is associated with increased maternal and neonatal morbidity [9]. Although there are known risk factors, there are no proven interventions to reduce risk of macrosomia, and previous high-quality studies failed to demonstrate efficacy [34]. Modifiable factors such as excessive maternal weight gain are linked to fetal macrosomia, however, and this should motivate further work into effective preventative strategies. Additionally, there is a major paucity of essential data on long-term pelvic floor outcomes with management of macrosomia. High-quality studies on this research question are essential in comprehensively guiding women through decisions on delivery.

Clinical implications

This study obtained valuable data as delivery decisions were made collaboratively between the woman and her obstetric team. These outcomes can be used to further inform such discussions. The management of fetal macrosomia is controversial and international consensus groups have struggled to come to a unanimous conclusion on best practice. New guidance from NICE considers risks of active versus

expectant management but concludes that after discussion of risk, maternal preference should be the guiding factor [26]. With the new findings of this study identifying additional burden of morbidity on nulliparous women with a low Bishops score, the authors suggest an assessment of the cervix at 38–39 weeks' gestation in the setting of fetal macrosomia, and tailoring decision-making around this. We highlight that nulliparous woman with an unfavorable cervix has an elevated risk of OASIs and postpartum hemorrhage. In this cohort, it should be discussed with the woman that expectant management may allow natural cervical ripening without elevating the risk of maternal morbidity. In those proceeding with active management, there should be an awareness of their elevated risk of hemorrhage and perineal morbidity, with employment of appropriate preventative strategies. Shared decision-making with patients is paramount in managing non-diabetic macrosomia and data from this study will inform individualized patient care.

Conclusions

This cohort study of women diagnosed with fetal macrosomia at an Irish tertiary obstetric unit found no difference in maternal or neonatal outcomes between women opting for active versus expectant management. Active management did not confer protection again adverse neonatal outcomes. Women with expectant management were more likely to go into spontaneous labor but have higher rates of episiotomy. With active management, nulliparous women with an unfavorable cervix at induction are more likely to have higher rates of obstetric anal sphincter injury and increased rates of postpartum hemorrhage. Individualized discussions between the woman and her obstetrician are essential to achieve an informed and balanced decision.

Author contribution Study concept was by AM. Study design was by GAC and AM. Data acquisition was by EMcN, GAC, SH, and AJ. Data analysis was by GAC and SWL. Result interpretation was by GAC, SH, AJ, EMcN, SWL, MPOC, and AM. Manuscript was drafted by GAC and was critically reviewed by SH, AJ, EMcN, SWL, MPOC, and AM. Final approval of the published manuscript has been agreed by all authors.

Author data sharing statement Individual participant data will only be available in its anonymous form, with no identifiable data to preserve the privacy and confidential of the subjects. Data will be available on reasonable request from the corresponding author.

Declarations

Ethics approval Approval for this review of local practice and outcomes was granted by the institution's clinical governance board.

Informed consent Informed consent was obtained from all individuals included in this study.

Conflict of interest The authors declare no competing interests.

References

1. Spellacy WN, Miller S, Winegar A, Peterson PQ (1985) Macrosomia–maternal characteristics and infant complications. Obstet Gynecol 66(2):158–161
2. San Aye S, Miller V, Saxena S, Farhan M (2011) Management of large-for-gestational-age pregnancy in non-diabetic women. The Obstetrician & Gynaecologist: Wiley
3. Goldman GA, Kaplan B, Neri A et al (1995) The grand multipara. Eur J Obstet Gynecol Reprod Biol 61(2):105–109. https://doi.org/10.1016/0301-2115(95)02108-j
4. Reynolds CME, Egan B, McMahon L et al (2019) Maternal obesity trends in a large Irish university hospital. Eur J Obstet Gynecol Reprod Biol 238:95–99. https://doi.org/10.1016/j.ejogrb.2019.05.003
5. Walsh JM, Mahony R, Byrne J et al (2011) The association of maternal and fetal glucose homeostasis with fetal adiposity and birthweight. Eur J Obstet Gynecol Reprod Biol 159(2):338–341. https://doi.org/10.1016/j.ejogrb.2011.09.022
6. Hawthorne G, Robson S, Ryall EA et al (1997) Prospective population based survey of outcome of pregnancy in diabetic women: results of the Northern Diabetic Pregnancy Audit, 1994. BMJ 315(7103):279–281. https://doi.org/10.1136/bmj.315.7103.279
7. McMahon LE, O'Malley EG, Reynolds CME, Turner MJ (2020) The impact of revised diagnostic criteria on hospital trends in gestational diabetes mellitus rates in a high income country. BMC Health Serv Res 20(1):795. https://doi.org/10.1186/s12913-020-05655-y
8. Tian C, Hu C, He X et al (2016) Excessive weight gain during pregnancy and risk of macrosomia: a meta-analysis. Arch Gynecol Obstet 293(1):29–35. https://doi.org/10.1007/s00404-015-3825-8
9. Beta J, Khan N, Fiolna M et al (2019) Maternal and neonatal complications of fetal macrosomia: cohort study. Ultrasound Obstet Gynecol 54(3):319–325. https://doi.org/10.1002/uog.20278
10. Lloreda-García JM, Sevilla-Denia S, Rodríguez-Sánchez A et al (2016) Perinatal outcome of macrosomic infants born to diabetic versus non-diabetic mothers. Endocrinol Nutr 63(8):409–413. https://doi.org/10.1016/j.endonu.2016.04.010
11. Farren M, Turner M (2016) Can fetal macrosomia be predicted and prevented?, 3rd edn. CRC Press/Taylor & Francis, Textbook of Diabetes and Pregnancy
12. Mongelli M, Benzie R (2005) Ultrasound diagnosis of fetal macrosomia: a comparison of weight prediction models using computer simulation. Ultrasound Obstet Gynecol 26(5):500–503. https://doi.org/10.1002/uog.1989
13. Zafman KB, Bergh E, Fox NS (2020) Accuracy of sonographic estimated fetal weight in suspected macrosomia: the likelihood of overestimating and underestimating the true birthweight. J Matern Fetal Neonatal Med 33(6):967–972. https://doi.org/10.1080/14767058.2018.1511697
14. NICE NIfHaCE (2012) Caesarean section. Clin Guideline 132
15. Horvath K, Koch K, Jeitler K et al (2010) Effects of treatment in women with gestational diabetes mellitus: systematic review and meta-analysis. BMJ 340:c1395. https://doi.org/10.1136/bmj.c1395
16. Metcalfe A, Hutcheon JA, Sabr Y et al (2020) Timing of delivery in women with diabetes: a population-based study. Acta Obstet Gynecol Scand 99(3):341–349. https://doi.org/10.1111/aogs.13761

17. Magro-Malosso ER, Saccone G, Chen M et al (2017) Induction of labour for suspected macrosomia at term in non-diabetic women: a systematic review and meta-analysis of randomized controlled trials. BJOG. 02 124(3):414–421. https://doi.org/10.1111/1471-0528.14435
18. Boulvain M, Irion O, Dowswell T, Thornton JG (2016) Induction of labour at or near term for suspected fetal macrosomia. Cochrane Database Syst Rev (5):CD000938. https://doi.org/10.1002/14651858.CD000938.pub2
19. Vitner D, Bleicher I, Kadour-Peero E et al (2020) Induction of labor versus expectant management among women with macrosomic neonates: a retrospective study. J Matern Fetal Neonatal Med 33(11):1831–1839. https://doi.org/10.1080/14767058.2018.1531121
20. Souter I, Smith KW, Dimitriadis I et al (2013) The association of bisphenol-A urinary concentrations with antral follicle counts and other measures of ovarian reserve in women undergoing infertility treatments. Reprod Toxicol 42:224–231. https://doi.org/10.1016/j.reprotox.2013.09.008
21. NICE (2017) Intrapartum care for healthy women and babies
22. IOG (2014) Prevention and management of primary postpartum haemorrhage. In: Gynaecologists IoOa, editor
23. Sultan AH (1999) Obstetric perineal injury and anal incontinence. Clin Risk
24. Fernando RJ, Williams AA, Adams EJ (2015) The management of third and fourth degree perineal tears. RCOG Green-top Guidelines
25. Moldéus K, Cheng YW, Wikström AK, Stephansson O (2017) Induction of labor versus expectant management of large-for-gestational-age infants in nulliparous women. PLoS ONE 12(7):e0180748. https://doi.org/10.1371/journal.pone.0180748
26. NICE (2021) Inducing Labour NG207. NICE: National Institute for Care and Excellence
27. Rozenberg P (2016) In case of fetal macrosomia, the best strategy is the induction of labor at 38 weeks of gestation. J Gynecol Obstet Biol Reprod (Paris) 45(9):1037–1044. https://doi.org/10.1016/j.jgyn.2016.09.001
28. Grobman WA, Rice MM, Reddy UM et al (2018) Labor induction versus expectant management in low-risk nulliparous women. N Engl J Med 379(6):513–523. https://doi.org/10.1056/NEJMoa1800566
29. Hospital CWaIU (2020) Annual clinical report 2020. In: Sheehan S, editor
30. Mullally A, Vallejo N, Banks R et al (2018) Reducing obstetric anal sphincter injuries (OASIs) in childbirth: a quality improvement project. Wiley, BJOG
31. Eftekhar T, Hajibaratali B, Ramezanzadeh F, Shariat M (2006) Postpartum evaluation of stress urinary incontinence among primiparas. Int J Gynaecol Obstet 94(2):114–118. https://doi.org/10.1016/j.ijgo.2006.04.042
32. Baracho SM, Barbosa da Silva L, Baracho E et al (2012) Pelvic floor muscle strength predicts stress urinary incontinence in primiparous women after vaginal delivery. Int Urogynecol J 23(7):899–906. https://doi.org/10.1007/s00192-012-1681-7
33. Brown SJ, Gartland D, Donath S, MacArthur C (2011) Effects of prolonged second stage, method of birth, timing of caesarean section and other obstetric risk factors on postnatal urinary incontinence: an Australian nulliparous cohort study. BJOG 118(8):991–1000. https://doi.org/10.1111/j.1471-0528.2011.02928.x
34. Walsh JM, McGowan CA, Mahony R (2012) Low glycaemic index diet in pregnancy to prevent macrosomia (ROLO study): randomised control trial. BMJ 345:e5605. https://doi.org/10.1136/bmj.e5605