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Foetal macrosomia — incidence, determinants and neonatal outcomes: 10-years retrospective review, 2010–2019

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ABSTRACT

Objectives: Prevalence of macrosomia differs worldwide according to studied population and has been variable over last few decades. The objective of the study was to determine the trends in incidence and clinical characteristics of infants with macrosomia born in two diverse Polish neonatal centres from 2010–2019.

Material and methods: Trends in the incidence of macrosomia, maternal age, delivery mode and neonatal complications were analysed over a 10 year period based on birth medical records.

Results: The total number of 43 165 term neonates were analysed with macrosomia incidence of 16.63% (n = 7179). The prevalence of macrosomia was stable from 2010–2019 irrespectively of referentiality and geographical area. Mean maternal age increased over the decade with higher age of mothers of macrosomic neonates. Recognizability of gestation diabetes among pregnant women increased from 9.61% in 2010 to 15.27% in 2019 and it was comparable in mothers of macrosomic infants. The percentage of caesarean sections was higher in macrosomic neonates and gradually increased over last decade. The highest percentage of birth injuries was observed in the first grade of macrosomia (4000–4499 g). The number of neonatal complications including lower Apgar score, respiratory and cardiology symptoms correlated with severity of macrosomia, with highest morbidity in children above 5000 g.

Conclusions: The prevalence of macrosomia in the studied cohort remained invariable over the last decade. Macrosomia is associated with an increased rate of caesarean sections, higher maternal age and increased neonatal morbidity. A higher macrosomia grade is related to a worse neonatal outcome. Further studies on other risk factors of macrosomia are needed.

Key words: foetal macrosomia; birthweight; growth acceleration; gestation diabetes

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INTRODUCTION

Foetal macrosomia is defined as birthweight of beyond 4000 g regardless of gestation age. Three grades of foetal macrosomia include: 1st grade 4000–4499 g, 2nd grade 4500–4999 g, 3rd grade of 5000 g and more.

The incidence of foetal macrosomia varies worldwide depending on studied population (Denmark: 20%, Australia 12.8%, USA 8.07%, China 7.83%, Israel 4.4%, Japan 0.9%) [1–7].

Global growth acceleration and increased incidence of foetal macrosomia have been observed over the past several decades. Long-term reviews describe the increase of macrosomia over the years due to improved maternal nutrition, reduced nicotine intake during pregnancy, raised maternal age, higher pre-gestational body mass index (BMI) and considered to be most relevant — increased gestational weight gain [8, 9]. Significant birth weight acceleration and increasing prevalence of foetal macrosomia has been observed particularly in Nordic countries [2]. For instance, in Aarhus, Denmark the percentage of children born with birth weight above 4000 g increased from 16.7% in 1990 to 20%

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in 1999 [3]. An increasing trend of foetal macrosomia has been observed regardless the geographical area. In Queens, Australia a 17-year observation revealed an increase of foetal macrosomia from 12.2% to 12.8% [4].

Contrary to that, in some countries rising trends in foetal macrosomia has been reversed over the last 2 decades. Current studies reveal the decline in prevalence of macrosomia in United States of America, China and Brazil [1, 6, 10]. These results have been supported by the improvement of obstetric care, especially management of gestation diabetes [1]. In China, a 20-year review revealed an increase of macrosomia from 6% to 8.49% between 1994–2000 and following subsequent decline in 2005 to 7.83% [6]. The longest study (47 years) from United States conducted between 1971–2017 revealed initial increase of macrosomia from 8.84% to 11.8% in 1985 followed by a subsequent drop to 8.07% by the end of the study [1].

Complications of foetal macrosomia includes numerous aspects of perinatology: traumatic delivery, maternal and neonatal complications such as birth injuries, cardiology and respiratory failure and metabolic abnormalities that may significantly affect further physical development [11]. Long-term consequences of foetal macrosomia include diabetes, metabolic syndrome, obesity and asthma [12–14]. The risk of significant complications correlates with macrosomia grade [15, 16]. Although the risk of mortality and morbidity in the first stage of macrosomia is comparable to the general population, in children born with weight of 4500 g and more the risk of neonatal mortality is significantly higher [16, 17].

So far there has been no long-term study including the incidence, trends and phenotype of Polish infants with foetal macrosomia. Despite the implementation of widely applied guidelines of Polish Obstetrics and Gynaecology Society including appropriate management of pregnant women with risk of foetal macrosomia, still there are no neonatal guidelines regarding clinical management of large infants [18]. Due to common phenomenon of acceleration in birthweight, it is essential to revaluate potential risks and complications depending on grades of macrosomia and assess in which infants' additional clinical management should be applied.

Objectives

The aim of the study was to determine clinical characteristics of infants with foetal macrosomia born in two diverse Polish neonatal centres between 2010–2019.

Authors attempted to assess the variability of incidence in macrosomic births in studied population over a 10-year observation. In addition, the study aimed to assess two various cohorts of neonates born in distinct geographic area, different referentiality centres and to evaluate clinical complications according to applied perinatal management and grade of foetal macrosomia.

MATERIAL AND METHODS

The study retrospectively reviewed a population of 43 156 term live births (gestation age of 37 and more) from 2010–2019 in 2 various neonatal centres. Pre-term infants of < 37 gestation weeks were excluded from the study.

First cohort of patients included 27 465 term births from second stage referentiality Neonatal Unit in Wejherowo Specialistic Hospital. The second cohort included 15 691 term births delivered in third stage referentiality Department of Neonatology in University Hospital No. 2 in Bydgoszcz.

Studied cohorts were assessed separately and combined. Trends in the incidence of macrosomia and variability of maternal age were analysed over a 10-year period.

Data collected from birth medical records included: maternal age, birth weight, gender, mode of delivery, Apgar score, maternal complications including gestational diabetes, neonatal complications including birth injuries, respiratory, cardiological complications and jaundice. Birth injuries were divided into clavicular fracture, brachial plexus palsy and head injuries (caput succedaneum, cephalohaematoma and subaponeurotic haematoma).

Based on the recommended classification in the literature macrosomia was defined as birth weight ≥ 4000 g. The analysis of macrosomia phenotype included 3 grades: 1st grade 4000–4499 g, 2nd grade 4500–4999 g, 3rd grade ≥ 5000 g.

Macrosomic births were compared to controlled group of all term births.

Statistical analyses were performed using Wizard 2.0 (Evan Miller Chicago, IL). Categorical variables were expressed as count (n) and percentages. Continuous variables were expressed as mean ± standard deviation or median (minimum–maximum) dependently on the distribution. Normality of distribution was tested using Shapiro-Wilk test. Student t-test or ANOVA and Mann-Whitney or Kruskal-Wallis tests were used as appropriate. Categorical data was compared with a chi-squared test. Statistical significance (p) less than 0.05 was considered significant.

Approval for the study was granted by Bioethical Committee of Medical University in Torun, *Collegium Medicum* in Bydgoszcz (KB 356/2020).

RESULTS

During the study period 48910 live births were analysed in two described medical centres. Preterm births of < 37 gestation age (5754, 11.8%) were excluded from the study. Remaining 43 165 term births were analysed.

Foetal macrosomia was observed in 7179 (16.63%) infants with following grade distribution: 1st grade

Table 1. Characteristics of studied cohorts according to referentiality centres

	Neonatal Unit with Intensive Care in Wejherowo, Pomeranian Hospitals (2nd stage of referentiality)				Department of Neonatology University Hospital No 2 in Bydgoszcz (3rd stage of referentiality)			
	All term births		Foetal macrosomia (≥ 4000 g)		All term births		Foetal macrosomia (≥ 4000 g)	
	27465	100%	5026	18.30%	15691	100%	2153	13.72%
Male	14017	51.04%	3178	63.23%	8137	51.86%	1412	65.58%
Female	13448	48.96%	1848	36.77%	7551	48.12%	741	34.42%

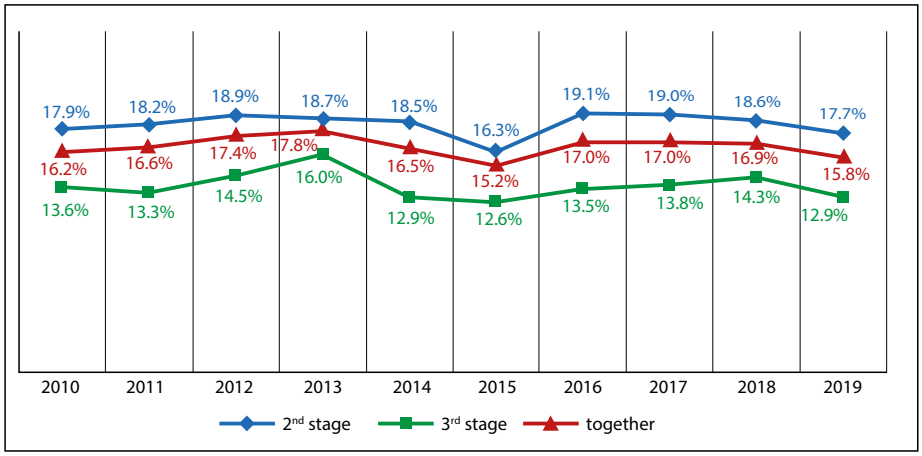

Figure 1. Incidence of macrosomia from 2010–2019 together (p = 0.092) and according to studied referentiality medical centre (2nd stage: p = 0.442, 3rd stage: p = 0.266)

5953 (13.79% of term births, 82.92% of macrosomic births), 2nd grade 1104 (2.56% of term births, 15.38% of macrosomic births), 3rd grade 122 (0.28% of term births, 1.7% of macrosomic births). The percentage of macrosomic infants was higher in 2nd stage referentiality unit (n = 5026, 18.3%) comparing to 3rd stage referentiality unit (n = 2153, 13.72%) (p < 0.001) In both cohorts, prevalence of macrosomia was higher in males (Tab. 1)

During a 10 year observation period no significant change in foetal macrosomia incidence was observed separate in each medical centre and all together (p = 0.092) (Fig. 1).

Maternal age

In both compared cohorts of mothers: mothers in total and mothers of macrosomic infants increase of maternal age was observed over a 10-year duration of the study (Tab. 2).

Although over a 10-year observation in total, mothers of macrosomic infants (n = 7196, mean age 29.55 ± 4.99 years) were older in comparison to mothers of all term infants (n = 43165, mean age 29.25 ± 5.25) (p < 0.001), at the end of the study, in year 2019 the age of macrosomic mothers and others was comparable (p = 0.95) (Fig. 2).

Table 2. Increase of maternal age (years) in studied cohorts between the years 2010–2019

Mean maternal age	2010	2019	p value
All infants > 37 hbd	28.62 ± 5.12	29.82 ± 5.31	< 0.0001
Macrosomic infants	28.81 ± 4.94	29.81 ± 4.94	< 0.001

Gestational diabetes mellitus

Analysed medical records revealed 4577 mothers with diagnosed gestational diabetes mellitus (GDM) (10.61%). The percentage of gestational diabetes in mothers of macrosomic infants was 10.25% (n = 7197) and was comparable to general population (p = 0.29). Figure 3 presents different GDM distribution according to referentiality centre. Regardless of analysed centre there was no significant difference of prevalence of GDM in mothers of macrosomic infants comparing to general population (2nd stage centre p = 0.05, 3rd stage centre p = 0.10).

Recognizability of gestational diabetes among pregnant women gradually increased over a study period from 9.61% in 2010 to 15.27% in 2019.

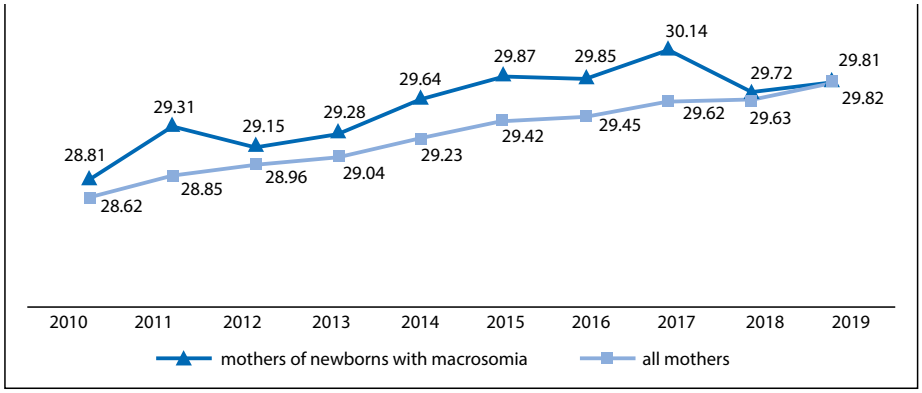

Figure 2. Distribution of mean maternal age (years) in 2010–2019 in macrosomic infants and all births

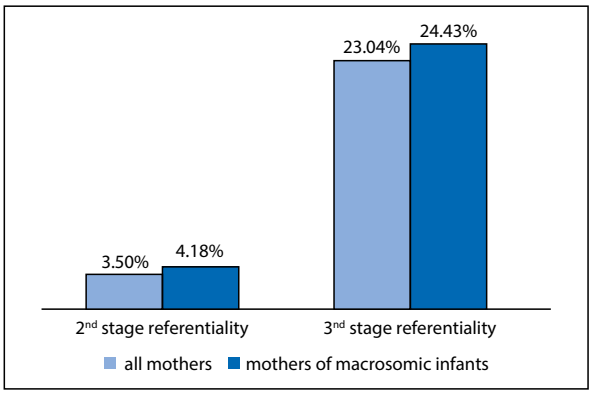

Figure 3. Percentage of gestational diabetes among pregnant women with distribution to referentiality centres

Due to limited data, it was not possible to analyse distribution of various types of gestational diabetes (Fig. 4).

Delivery mode

In studied cohort 32378 infants were born by vaginal delivery (VD) (75.03%) and 10 778 by caesarean section (CS) (24.97%). In 970 of infants delivered vaginaly (n = 970, 2.25%) vacuum or forceps were applied. In macrosomic infants increased number of caesarean sections (n = 2242, 31.23%, $p < 0.001$) and decreased number of vacuum/forceps delivery were observed (n = 143, 1.99%, $p < 0.001$) comparing to all infants.

Over 10-years the percentage of caesarean section deliveries significantly increased in total from 20.31% in 2010 to 29.26% in 2019 (Pearson correlation, $p < 0.001$, $r = 0.062$, $r^2 = 0.004$). Caesarean section deliveries of macrosomic infants also increased and ranged from 24.01% in 2010 to 38.25% in 2019 (Pearson correlation, $p < 0.001$, $r = 0.093$, $r^2 = 0.009$) (Fig. 5).

Figure 5 presents different rates of caesarean section deliveries according to referentiality centre.

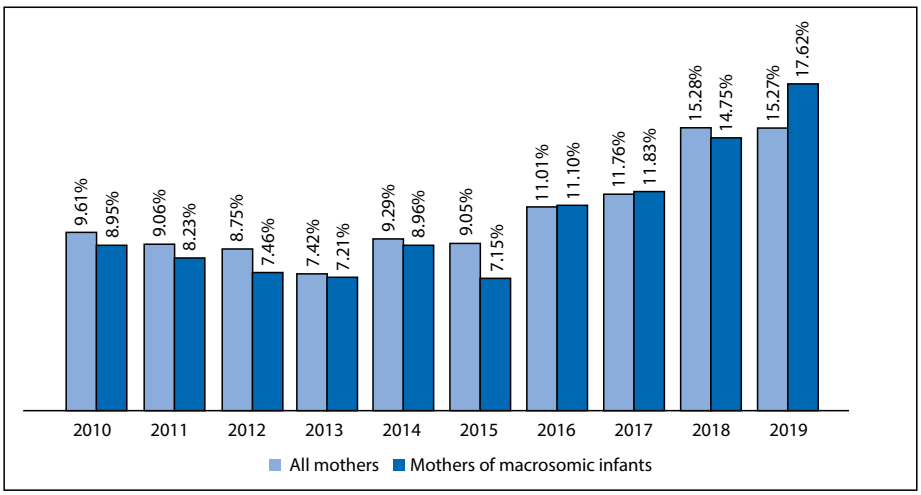

Figure 4. Recognizability of gestational diabetes among pregnant women in studied cohort during years 2010–2019

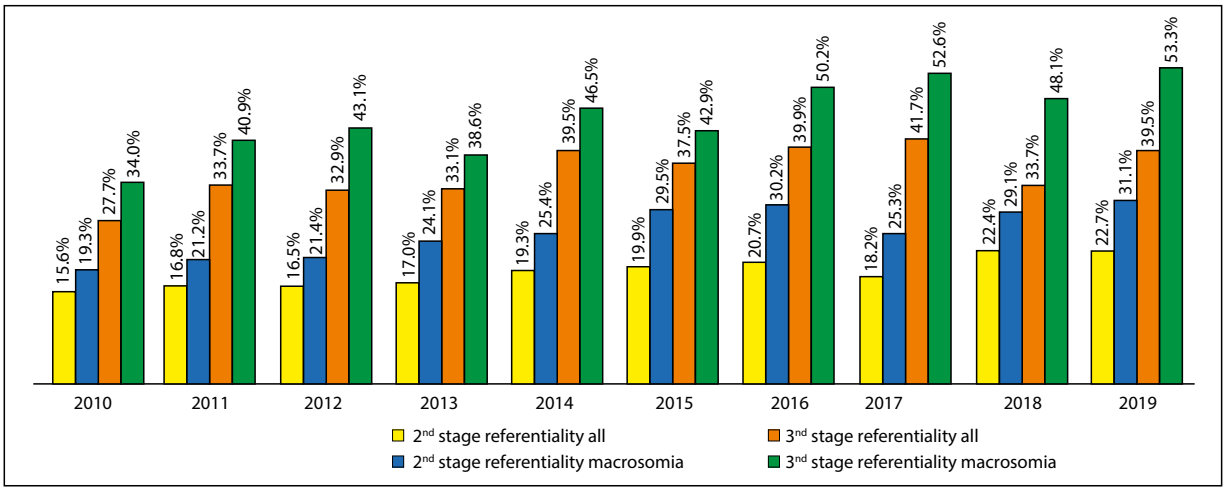

Figure 5. Rate of caesarean section delivery in studied cohorts from 2010–2019

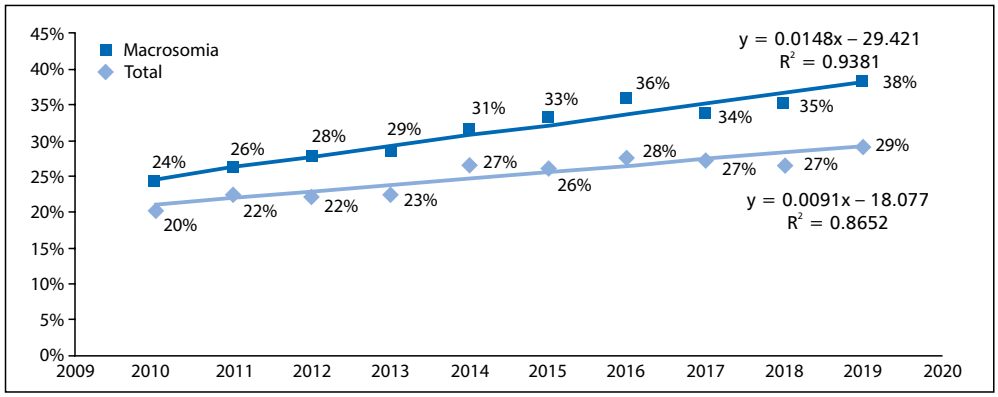

Figure 6. Rate of caesarean section deliveries in years 2010–2019 in total and in macrosomic deliveries

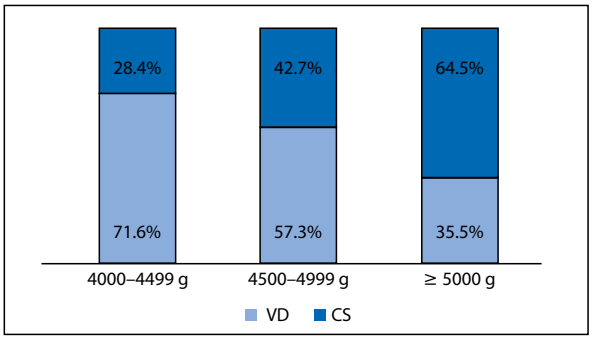

Figure 7. Increase of percentage of caesarean sections (CS) versus vaginal delivery (VD) according to macrosomia grade

The percentage of performed caesarean sections increased according to macrosomia grades with the highest percentage of 64.5% in infants with birthweight of 5000 g and more (Fig. 7).

Number of performed forceps or vacuum delivery decreased from 2.2% of infants with first grade macrosomia to 0.8% of infants with 3rd grade ($p < 0.0001$) (Fig. 6).

Perinatal complications

Cohort of macrosomic infants in both centres was characterised by increased number of birth injuries including head injury (caput succedaneum, cephalohaematoma and subaponeurotic haematoma), clavicular fracture and brachial plexus injury. Cardiovascular symptoms such as cyanosis, heart murmur or abnormal pulsoximetry test included 7.06% of macrosomic infants in comparison to 5.56% of all infants ($p < 0.001$). There was no difference in prevalence of respiratory symptoms in macrosomic infants comparing to other infants. Jaundice was observed significantly less frequently in macrosomia cohort ($p < 0.001$) (Tab. 3).

Distribution of perinatal complications was also analysed according to macrosomia grades. Birth injuries gradually de-

Table 3. Perinatal complications in studied cohorts

	All infants (n = 43165)	%	Macrosomia (n = 7196)	%	p value
Birth injuries					
Head injuries	750	1.74	102	1.42	0.024
Clavicular fracture	157	0.36	59	0.82	< 0.001
Brachial plexus injuries	23	0.05	12	0.17	< 0.001
Other complications					
Cardiovascular	2403	5.57	507	7.062	< 0.001
Respiratory	903	2.09	156	2.883	0.61
Jaundice	2264	5.25	316	4.402	< 0.001

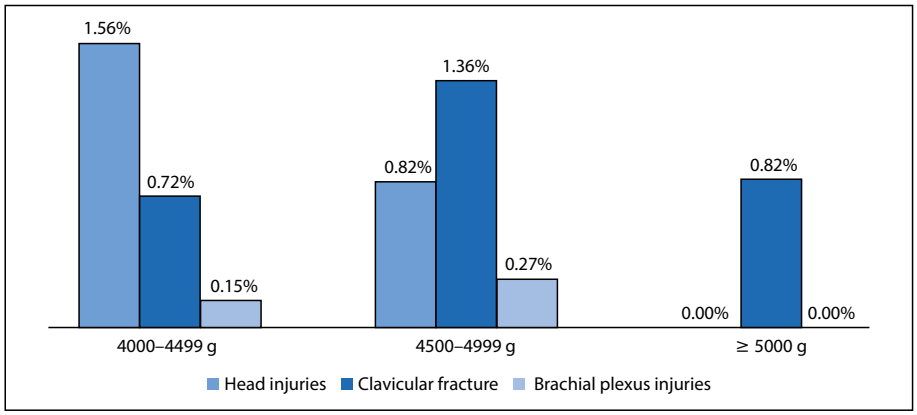

Figure 8. Percentage of birth injuries according to macrosomia grade

creased in subsequent macrosomia grades, what correlated with increasing percentage of caesarean sections and decreasing prevalence of vacuum and forceps deliveries. Number of head injuries significantly decreased in each macrosomia grade (1st grade: n = 93, 1.56%; 2nd grade: n = 9, 0.82%, p = 0.031; 3rd grade: n = 0, 0%, p = 0.017). Clavicular fractures were observed most frequently in 2nd grade of macrosomia (n = 15, 1.36% in 2nd grade vs n = 43, 0.72% in 1st grade, p = 0.031) and its percentage decreased in 3rd grade (n = 1, 0.82%, p = 0.013) (Fig. 8). Brachial plexus injuries were observed most frequently in 2nd grade macrosomia (n = 3, 0.27%), however there was no statistical difference between other grades of macrosomia (1st grade: n = 9, 0.15% vs 2nd grade: n = 3, 0.27%, p = 0.37; 2nd grade vs 3rd grade: n = 0, 0%, p = 0.25) (Fig. 9).

Increase of macrosomia grade was also related to decreased Apgar score in first minute after birth (p = 0.001) (Fig. 10).

All studied complications including cardiovascular symptoms, respiratory symptoms and jaundice were increasing in further macrosomia grades with highest percentage in 3rd grade macrosomia (p < 0.001, p = 0.006, p = 0.012) (Fig. 9).

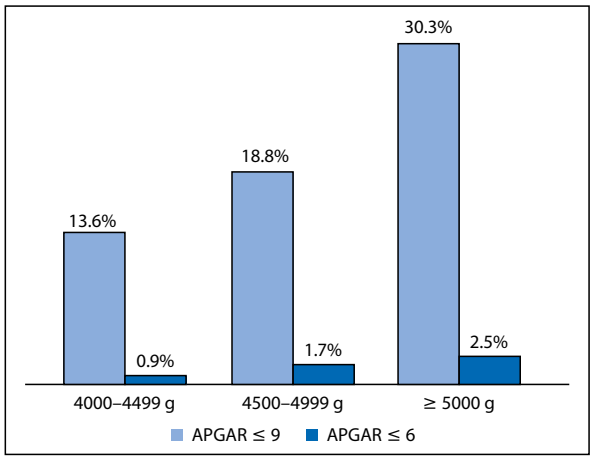

Figure 9. Percentage of cardiovascular, respiratory complications and jaundice according to macrosomia grades

DISCUSSION

Authors of the study analysed so far, the largest cohort of polish neonates regarding foetal macrosomia and managed to observe its prevalence over last decade.

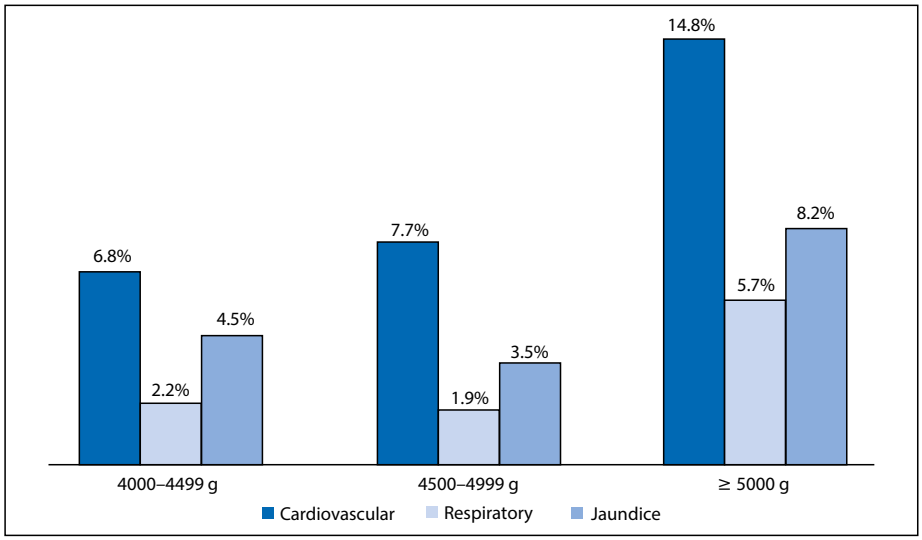

Figure 10. Percentage of decreased Apgar score in first minute of life according to macrosomia grade

Although large for gestational age (LGA) would be more adequate measure of excessive foetal growth, macrosomia grades (> 4000 g, > 4500 g, > 5000 g) more appropriately apply to perinatal standards and procedures [18]. Macrosomia with described weight compartments is also more frequently analysed in current international literature and it seems to be more consistent in view of more heterogeneous population.

The authors examined the trends in foetal macrosomia in 43 165 term neonates from 2 heterogenous medical centres. The centres were characterized of various geographical area and different referentiality stage, what applied to some of the results. 3rd stage referentiality centre in Bydgoszcz was dedicated to potentially high-risk pregnancies, what was related to higher rate of maternal morbidity such as gestational diabetes, increased rate of prematurity and higher rate of Casearean section deliveries.

Despite these differences in studied cohorts, authors manage to achieve consistent findings for both medical centres.

Overall incidence of macrosomia was 16.63% with higher incidence in 2nd stage Centre in Wejherowo comparing to 3rd stage Centre in Bydgoszcz. During the study period in both centres there was no significant change in its rate with baseline rate of 16.2% in 2010 and 15.8% at the end of the study. These results were inconsistent with decreasing trends in macrosomia observed in USA or China [1, 6]. Prevalence of macrosomia was more similar to described northern European cohorts [3]; however, the trend of macrosomia was stable in contrast to other countries [1, 3, 4, 6]. The longest and most current population-based study in USA revealed initial increase of macrosomia in first decade of the study with subsequent decrease in the following years [1]. In our cohort the macrosomia rate was stable, however long-term follow up in next decade would be crucial to analyse further trend.

Due to retrospective nature of the study and limited access to medical data authors managed to analyse only few risk factors of macrosomia including maternal age and gestation diabetes.

Increasing trend in maternal age of macrosomic mothers, as well as all mothers was observed over a 10-year study. Advanced maternal age is considered as an important risk factor for macrosomia what was confirmed by numerous publications [20]. In our study mothers of macrosomic infants were older in general. Increase of maternal age in macrosomic infants was subsequently observed from 2010–2017, however from 2018–2019 the mean age decreased and equalized with general population of mothers. Further observation of these trend needs to be performed.

Another risk factor related to foetal macrosomia is gestational diabetes. The incidence of GDM worldwide varies from 1 to 45% of pregnant women depending on studied population [21]. Among the Polish population, prevalence of GDM based on National Health found that in 2012 it was estimated as 7.45%, and the trend of its incidence was increasing [22]. In our study analysis of medical records in total revealed 10.61% of mothers diagnosed with gestational diabetes. Expected higher percentage of diabetic mothers in 3rd stage of referentiality was confirmed in the study. Prevalence of GDM in the study was higher than in general polish population, what can be explained by higher referentiality of our centres in comparison to general population. Regardless the stage of referentiality authors emphasise increasing trends in diagnosis of gestational diabetes over the last decade from 9.61% at the beginning of the study

to 15.27% in 2019 what is consistent with temporal trends in other countries [21, 22]. Although GDM is well known risk factor of foetal macrosomia in our cohort there was no significant difference of prevalence of GDM in mothers of macrosomic infants comparing to other infants, what is also consistent with some studies [23, 24].

Further study precisely assessing other risk factors including genetic factors such as parental birth weight, pre-gestational BMI, gestational weight gain and other is required.

Over the 10-year period the percentage of caesarean section deliveries significantly increased in studied cohort from 20.31% in year 2010 to 29.26% in 2019.

This trend of increase is observed overall in the Polish population [18], however the mean number of caesarean sections in analysed cohort was lower in comparison to general polish population with percentage of 43.85%.

The percentage of caesarean section deliveries of macrosomic infants was higher and ranged from 24.01% in 2010 to 38.25% in 2019. In 3rd stage referentiality centre the percentage of caesarean sections in macrosomic infants reached 53.3% in 2019 which is explained of increased number of high risks comparing to 2nd stage unit.

In addition, over the decade the number of vacuum/forceps deliveries gradually decreased with lower percentage of these procedures in macrosomia groups.

Grouping macrosomic infants into specific weight categories (macrosomia grades) has important implication in order to predict potential complications of foetal macrosomia [1, 13]. Authors noted that although the first grade of macrosomia (4000–4499 g) is the most common and less severe type of macrosomia is still related to increased incidence of birth trauma. These findings suggest that adequate perinatal care including caesarean section delivery should be considered in these group of patients with is consistent with current Polish and international recommendations [18, 19].

Authors also found 2nd and 3rd stage of macrosomia to be more severe types with increased perinatal complications regardless the mode of delivery. Higher macrosomia grades were related to increasing perinatal morbidity including lower Apgar score at birth and increased cardiovascular complications. The performed analysis showed no significant increase of respiratory symptoms and jaundice in macrosomia cohort; however, the number of these complications was significantly increasing with further macrosomia grades. These findings are consistent with international publications and impose the need of intensified medical attention in infants with macrosomia [1, 13, 15]. Higher perinatal morbidity of macrosomic infants should result in appropriate neonatal preparation in delivery room in order to perform effective NLS (Neonatal Life Support) procedures and intensified clinical attention in post-natal period.

CONCLUSIONS

The prevalence of macrosomia in studied cohort remained invariable over the last decade. Macrosomia is associated with increased rate of caesarean sections, increased maternal age and increased neonatal morbidity. Further studies on potential risk factors of macrosomia are needed.

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Conflict of interest

All authors declare no conflict of interest.

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