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REVIEW ARTICLE

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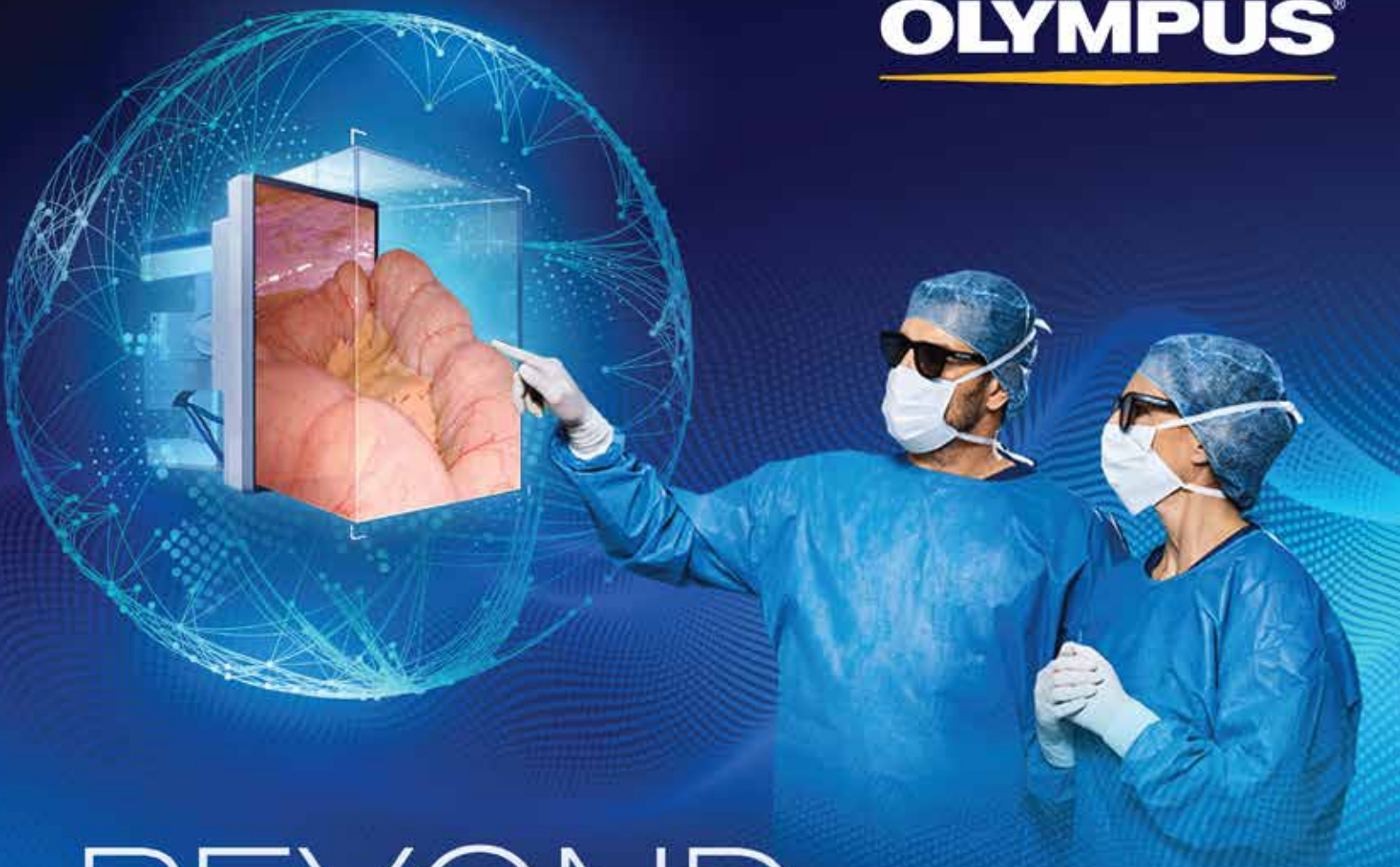

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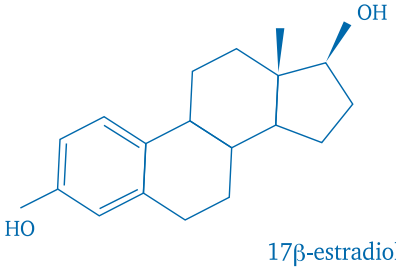

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- ovarian cancer
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- heart disease
- stroke
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Editorial
Recent changes in the Royal College of Obstetricians and Gynaecologists core curriculum

Although implementation of both Structured Oral Examination and Exit Examination for the Fellowship of the Hong Kong Academy of Medicine enables local control over evaluation of trainees for specialist status, the Members of the Royal College of Obstetricians and Gynaecologists (RCOG) examinations are still incorporated into training programmes. It is therefore imperative to equip both trainers and trainees with the requirements and updates in the RCOG training, in particular when there were substantial revisions to both the curriculum and the logbook in 2019.

The latest RCOG core curriculum was published in June 2019. Its development coincided with the preparation and publication of the generic professional capabilities framework by the General Medical Council of the United Kingdom. The latest curriculum shifts from a competency-based assessment on clinical skills and procedures alone to a significant increase in the proportion of non-technical skill training such as communication in a multidisciplinary setting, quality individualised care delivery, valuable research, and preparation for lifelong learning. It focuses on person-centred learning rather than the disease-based structure in the current training model. 14 capabilities in practice (CiP) under four professional identities are introduced (Table).

In Hong Kong, the current training model concentrates on the professional identity of clinical expert (CiP 9 to 12), with relatively minor, though valuable, input from the other three CiPs: quality improvement projects (in format of audits), research, and teaching. It is usually expected that other CiPs will 'automatically' be acquired when experience grows, such as teamwork, leadership, care of minorities/vulnerable groups, and public health mindset. In reality, it is not unusual to encounter highly knowledgeable and/or skilful trainees who are weak in these perspectives after years of training and even after completion. Therefore, including these CiPs in formal training programmes with specific training opportunities and assessment may lead to better patient satisfaction and outcomes in the patient-centred era.

In parallel with the expanded curriculum is the evidence to inform decision for trainers to ascertain minimal competency of each CiP at certain critical progression points and on completion of training. Apart from the OSATS (Objective Structured Assessment of Technical Skills), CbD (Case-based Discussions), and Mini-CEX (Mini-Clinical Evaluation Exercise), team observations (plus self-observation), non-technical skills for surgeons, and reflective practice are added. Members of the RCOG examination parts 1 to 3 are modified accordingly. Other formal evaluations include personal development plan and annual review of competence progression. Trainees are annually reviewed by a competence progression panel before progression to next year of training. External education assessor representing RCOG and lay representative are involved. Hong Kong College of Obstetricians and Gynaecologists and various training units need to determine whether and how the new tools and evaluations be used locally, with adequate training and briefing. This becomes increasingly complex when the training systems and practice environment in Hong Kong and United Kingdom differ. For example, the number of years of internship and specialist training are 1 year shorter in Hong Kong, and the local trainees usually stay in their training hospital rather than having regular rotation.

In the new RCOG curriculum logbook, the tick-box approach is replaced with a more self-initiated demonstration of progress and evaluation of their own performance at the expected rate. Quality is emphasised rather than quantity. In addition to being better tailored to each individual trainee's learning curve, this also has the benefit of showing competency in rare clinical circumstances through other methodologies such as simulation, drills, and web-based learning. Log of procedures is still required. The RCOG ePortfolio platform enables not only tracking of progress but also provision of online learning tools for trainees and supervisors to review training. This allows more regular updates and is more environmentally friendly (than the current paper-based system). The College's own electronic logbook may take some more time to complete given the change of the RCOG curriculum and the accompanying evaluations. Hopefully when it is ready, more accurate

Table. 14 capabilities in practice under four professional identities

Capability in practice	Description
Developing the doctor (generic)	
Healthcare professional	
1	The doctor is able to apply medical knowledge, clinical skills, and professional values for the provision of high-quality and safe patient-centred care
2	The doctor is able to successfully work within health organisations
3	The doctor is a leader who has vision, engages and delivers results
4	The doctor is able to design and implement quality improvement projects or interventions
5	The doctor understands and applies basic human factors principles and practice at individual, team, organisational and system levels
Researcher, scholar, and educator	
6	The doctor takes an active role in helping self and others to develop
7	The doctor is able to engage with research and promote innovation
8	The doctor is effective as a teacher and supervisor of healthcare professionals
Developing the obstetrician & gynaecologist (specialty-specific)	
Clinical expert	
9	The doctor is competent in recognising, assessing, and managing emergencies in gynaecology and early pregnancy
10	The doctor is competent in recognising, assessing and managing emergencies in obstetrics
11	The doctor is competent in recognising, assessing and managing non-emergency gynaecology and early pregnancy care
12	The doctor is competent in recognising, assessing and managing non-emergency obstetrics care
Champion for women's health	
13	The doctor is able to champion the healthcare needs of people from all groups within society
14	The doctor takes an active role in implementing public health priorities for women and works within local, national and international structures to promote health and prevent disease

recordings can be made during daily clinical practice.

Now that the more fundamental non-technical perspectives are formally considered to be as important as knowledge and technical skills, there is an urgency for our College, training units, trainers, and trainees to decide how our local model can adapt.

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Choice of public versus private hospital for maternity care: a cross-sectional questionnaire study

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Objective: To determine factors influencing the choice of public versus private hospital for maternity care and the satisfaction level of women on obstetric service.
Methods: Women who attended their first antenatal visit between 1 March 2018 and 30 April 2018 at the Pamela Youde Nethersole Eastern Hospital were contacted via telephone at 6 to 12 weeks after delivery to complete a questionnaire about (1) details of delivery, (2) factors affecting choice of hospital for maternal care, and (3) satisfaction towards obstetric services, whether to return to the same hospital for next delivery, and breastfeeding practices.
Results: 409 (89.1%) of 459 women completed the questionnaire. Of the 409 respondents, 308 (75.1%) delivered in our public hospital and 101 (24.6%) delivered in private hospitals. Those who chose to deliver in the private hospitals were more likely to be older (34.07 vs 32.56, p=0.007), primiparous (69.3% vs 52.3%, p=0.003), and have tertiary or higher education level (85.1% vs 54.9%, p<0.001). In the public hospital group, more women had normal vaginal delivery (57.5% vs 19.8%, p<0.001) and fewer women had Caesarean section (32.8% vs 77.2%, p<0.001). The private hospital group had higher rating for antenatal service, with more women rated ≥4 (94.1% vs 81.8%, p=0.024). More women in the public hospital group than in the private hospital group would return for next delivery (93.8% vs 86.1%, p=0.014) and practiced full or partial breastfeeding (91.6% vs 73.3%, p<0.001).
Conclusion: The overall rating to both public and private obstetric services in Hong Kong is good. 24.6% of women chose delivery at private hospitals for reasons such as having designated doctor-in-charge, choice on mode of delivery, and safety issue. The Caesarean section rate was higher in women who chose delivery at private hospitals. Further studies are warranted to investigate the reasons why these women prefer Caesarean delivery.

Keywords: Hospitals, private; Hospitals, public; Obstetrics; Patient satisfaction; Surveys and questionnaires

Introduction

In Hong Kong, the healthcare system comprises public and private sectors. Both sectors cover primary to tertiary levels of care, including obstetric service. Pregnant women are free to choose between public and private hospitals for antenatal care, delivery, and postnatal care. Some women even choose to receive antenatal care in both sectors and to deliver in either sector.

There are eight public hospitals in Hong Kong that provide obstetric services. When the viability of pregnancy is confirmed, Hong Kong residents can register at one of the eight public hospitals for antenatal care free of charge. The antenatal services include assessments and routine screening tests; other specific tests such as structural scan may be included depending on the hospital service and indications. A flat rate of HK$100 (US$13) per day is charged for hospital stay before and after delivery, irrespective to the mode of delivery or tests performed. In 2006/2007, the government subsidises 95% of the costs[1].

Private hospitals provide more personalised and accessible services to those who can afford. The Department of Health regulates all private hospitals and clinics under the Medical Clinics Ordinance. Private hospitals adopt a market principle, and prices are based on the cost of medical services and demand. Pregnant women can choose the attending doctors, antenatal services, and the mode and time of delivery.

In recent years, pregnant women commonly express the wish to deliver at private hospitals during antenatal follow-up at public hospital. When comparing the number of registered antenatal cases and the number of deliveries in our unit (Figure 1), around one-third of women who registered for antenatal care did not deliver in our unit. The aim of the present study was to determine factors

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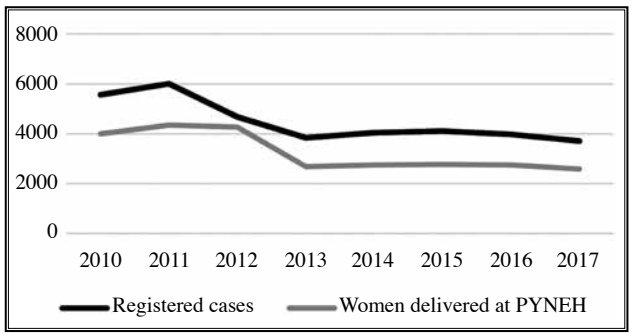

Figure 1. The number of registered antenatal cases and the number of deliveries at Pamela Youde Nethersole Eastern Hospital (PYNEH).

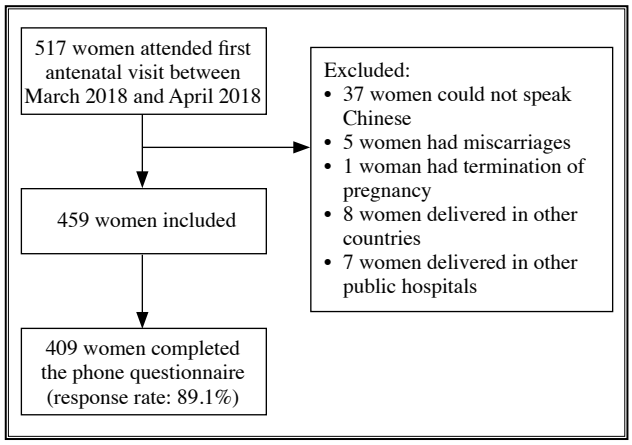

Figure 2. Flowchart for recruitment

influencing the choice of public versus private hospital for maternity care and the satisfaction level of women on obstetric service.

Methods

This cross-sectional study was approved by the Hong Kong East Cluster Research Ethics Committee (reference no.: HKECREC-2019-017). Medical records of pregnant women who attended their first antenatal visit between 1 March 2018 and 30 April 2018 at the Pamela Youde Nethersole Eastern Hospital were retrieved from the clinical management system. Those aged <18 years or those who could not speak Chinese were excluded, as were those who had miscarriage eventually or who delivered in other public hospitals or countries. Women were contacted via telephone at 6 to 12 weeks after delivery to complete a questionnaire (Appendix). The purpose and nature of the study were explained; verbal informed consent was obtained before participation. Failure to contact was declared after 4 unsuccessful attempts.

There was no validated questionnaire to assess women's satisfaction towards obstetric service. Therefore, relevant questions were designed based on studies on similar topics[2,3]. The questionnaire was divided into three parts: (1) details of delivery, including the place of delivery, gestation, mode of delivery, and reasons for operative delivery; (2) factors affecting choice of hospital for maternal care, including convenience, economical factor, safety, paediatric support, designated doctor-in-charge, choice of mode of delivery, choice of specific hospital, and choice of delivery time; and (3) satisfaction towards obstetric services in a scale of 1 to 5 (very poor to very good) in terms of antenatal service, labour ward/operative delivery service, and postnatal service; whether to return to the same hospital for next delivery; breastfeeding practices (full, partial, or not breast feeding), and any other comments regarding obstetric service.

The sample size was estimated using an online calculator[4]. In 2012 to 2016, the mean annual number of patients who booked our antenatal service was 4018, which was used as the number of patients booked in 2018. The confidence limit was taken as 5% and the variance as 2. To achieve a confidence level of 90%, the necessary sample size was estimated to be 406.

Statistical analyses was conducted using SPSS (Windows version 23.0, IBM Corp, Armonk [NY], USA). Women who gave birth in public or private hospital were compared using the Pearson Chi-square test or Fisher's exact test for categorical variables and the Mann-Whitney *U* test for continuous variables with a highly skewed distribution. A p value of <0.05 was considered statistically significant.

Results

Of 517 women attended their first antenatal visit during the study period, 58 were excluded because of inability to speak Chinese (n=37), miscarriage (n=4), termination of pregnancy (n=1), delivery in other countries (n=8), and delivery in other public hospitals (n=7), and the remaining 459 were invited to participate. Of the latter, 409 (89.1%) completed the questionnaire (Figure 2).

Of the 409 respondents (mean age, 32.9 years), 308 (75.1%) delivered in our public hospital and 101 (24.6%) delivered in private hospitals. Those who chose to deliver in the private hospitals were more likely to be older (34.07 vs 32.56, p=0.007), primiparous (69.3% vs 52.3%, p=0.003), and have tertiary or higher education level (85.1% vs 54.9%, p<0.001) [Table 1]. Overall, 387 (94.6%) women delivered at or after term (37 weeks of

Table 1. Characteristics and mode of delivery of participants

	Overall (n=409)*	Public hospital group (n=308)*	Private hospital group (n=101)*	p Value
Age, y	32.93, 33 (30-36)	32.56, 33 (30-36)	34.07, 34 (32-37)	0.007
Parity				0.003
0	231 (56.5)	161 (52.3)	70 (69.3)	
1	151 (36.9)	120 (39.0)	31 (30.7)	
2	21 (5.1)	21 (6.8)	0 (0.0)	
3	4 (1.0)	4 (1.3)	0 (0.0)	
4	1 (0.2)	1 (0.3)	0 (0.0)	
5	1 (0.2)	1 (0.3)	0 (0.0)	
Smoking				0.042
Non-smoker	351 (85.8)	261 (84.7)	90 (89.1)	
Ex-smoker	23 (5.6)	15 (4.9)	8 (7.9)	
Smoker, stop at first trimester	35 (8.6)	32 (10.4)	3 (3.0)	
Drinking				0.696
Non-drinker	389 (95.6)	290 (94.8)	99(98.0)	
Ex-drinker	6 (1.5)	5 (1.6)	1 (1.0)	
Drinker, stop at first trimester	11 (2.7)	10 (3.3)	1 (1.0)	
Drinker, continue during pregnancy	1 (0.2)	1 (0.3)	0 (0.0)	
Educational level				<0.001
Primary	1 (0.2)	1 (0.3)	0 (0.0)	
Secondary	150 (36.7)	135 (43.8)	15 (14.7)	
Tertiary and higher	255 (62.3)	169 (54.9)	86 (85.1)	
Others	3 (0.7)	3 (1.0)	0 (0.0)	
Gestation				0.513
≥37 weeks	387 (94.6)	289 (93.8)	97 (97.0)	
34-36 weeks	19 (4.6)	16 (5.2)	3 (3.0)	
30-33 weeks	3 (0.7)	3 (1.0)	0 (0.0)	
Mode of delivery				<0.001
Normal vaginal delivery	197 (48.2)	176 (57.5)	19 (19.8)	
Vacuum extraction	26 (6.4)	23 (7.5)	3 (3.0)	
Low forceps delivery	6 (1.5)	6 (2.0)	0 (0.0)	
Caesarean section	179 (43.8)	100 (32.7)	78 (76.5)	
Intrauterine death	1 (0.2)	1 (0.3)	0 (0.0)	

* Data are presented as mean, median (interquartile range) or No. (%) of participants

gestation). The preterm birth rates were similar in public and private hospital groups (6.2% vs 3%). There was no premature birth <30 weeks of gestation. Overall, 197 (48.2%) women had normal vaginal delivery, 26 (6.4%) women had vacuum-assisted delivery, 6 (1.5%) women had forceps-assisted delivery, 179 (43.8%) women had Caesarean section, and one woman had intrauterine death of fetus and vaginal delivery. In the public hospital group, more women had normal vaginal delivery (57.5% vs 19.8%, p<0.001) and fewer women had Caesarean section (32.8% vs 77.2%, p<0.001) [Table 1]. The most common indication for Caesarean section was previous Caesarean section (38%) in the public hospital group and maternal request (56.4%) in the private hospital group (Table 2).

The most common reason for choosing private

Table 2. Indications for Caesarean section

Indication	Public hospital group (n=100)*	Private hospital group (n=78)*
Maternal request	0	44 (56.4)
Previous Caesarean section	38 (38)	14 (17.9)
Breech and other abnormal presentation	10 (10)	3 (3.8)
Fetal distress/pathological cardiotocography	15 (15)	1 (1.3)
Cephalopelvic disproportion	14 (14)	1 (1.3)
Failed induction of labour	16 (16)	1 (1.3)
Twins pregnancy	2 (2)	2 (2.6)
Severe pre-eclampsia	1 (1)	0
Pregnancy induced hypertension	0	1 (1.3)
Prelabour rupture of membrane	0	2 (2.6)
Cord round neck	0	3 (3.8)
Genital wart (secondary)	0	1 (1.3)
Suspected marcosomnia	0	1 (1.3)
Placenta previa	4 (4)	1 (1.3)
Oligohydramnios	0	1 (1.3)
Antepartum haemorrhage	0	1 (1.3)
Placental aging	0	1 (1.3)

* Data are presented as No. (%) of participants

Table 3. Rating for obstetrics service, return for next delivery, and breast-feeding practice

Item	Public hospital group (n=308)*	Private hospital group (n=102)*	p Value
Rating for antenatal service			0.024
1 (very bad)	1 (0.3)	0 (0.0)	
2 (bad)	7 (2.3)	0 (0.0)	
3 (neutral)	48 (15.6)	6 (5.9)	
4 (good)	133 (43.2)	45 (44.6)	
5 (very good)	119 (38.6)	50 (49.5)	
Rating for labour and delivery service			0.312
1 (very bad)	1 (0.3)	0 (0.0)	
2 (bad)	6 (1.9)	0 (0.0)	
3 (neutral)	23 (7.5)	4 (4.0)	
4 (good)	106 (34.4)	31 (30.7)	
5 (very good)	172 (55.8)	66 (65.3)	
Rating for postnatal service			0.553
1 (very bad)	0 (0.0)	0 (0.0)	
2 (bad)	6 (1.9)	0 (0.0)	
3 (neutral)	30 (9.7)	10 (9.9)	
4 (good)	104 (33.8)	39 (38.6)	
5 (very good)	168 (54.5)	52 (51.5.0)	
Return for next delivery			0.014
Yes	288 (93.8)	87 (86.1)	
No	19 (6.2)	14 (13.9)	
Breast-feeding			<0.001
Full	141 (45.8)	20 (19.8)	
Partial	141 (45.8)	54 (53.5)	
No	26 (8.4)	27 (26.7)	

* Data are presented as No. (%) of participants

hospital for delivery was designated doctor-in-charge (44.6%), followed by choice on mode of delivery (37.6%) and safety (27.7%). Whereas the most common reason for choosing public hospital for delivery was economical factor (48.1%), followed by convenience (46.4%), paediatric support (44.2%), and safety (40.6%). 10.7% of women also considered factors such as previous delivery experience and comments from friends and internet. For those who delivered at private hospitals and also registered in the public hospital for delivery, the common reasons cited were paediatric support (n=47, 46.5%), safety (n=43, 42.6%), economical factor (n=38, 37.6%), and convenience (n=12, 11.9%).

The public and private hospital groups were comparable in terms of rating for labour and delivery service (p=0.312) and postnatal service (p=0.553) [Table 3]. The private hospital group had higher rating for antenatal service, with more women rated ≥4 (94.1% vs 81.8%, p=0.024) [Table 3]. More women in the public hospital group than in the private hospital group would return for next delivery (93.8% vs 86.1%, p=0.014) and practiced full or partial breastfeeding (91.6% vs 73.3%, p<0.001) [Table 3].

Discussion

Telephone survey is effective for data collection has a higher response rate than paper- or web-based survey and can reduce self-selection bias[5]. The absence of face-to-face contact in a telephone interview may reduce response bias[6].

The Caesarean section rate is 32% in the United States[7], 34.9% in Mainland China, 27.4% in Taiwan, 35% in Hong Kong, and >45% in Brazil, Egypt, and Turkey[8]. In the present study, 24.6% of women chose to deliver in private hospitals, and one major factor was choice on mode of delivery (37.6%). The Caesarean section rate was 77.2% in the private hospital group and 32.8% in the public hospital group. The significantly higher Caesarean section rate in the private hospital group was mainly due to maternal request (56.4%). Fear of vaginal birth, the severe form of which is known as tokophobia, is a common reason[9], as are fear of childbirth and loss of control[10-12]. Caesarean section is viewed as a 'consumerist discourse' and a means of birth convenience[13]. The ability to choose the place, time, doctor for delivery can facilitate woman's employment and social engagement. However, Caesarean section on maternal request makes delivery into surgery and is associated with surgical risks and potentially heavier postpartum haemorrhage. Based on the principle of beneficence and non-maleficence, Caesarean section on maternal request is unjustifiable in terms of potential risks and benefits. The risk of morbid adherence of placenta and placenta previa increases in women with scarred uterus[14-16]. The incidence of anterior placenta previa and placenta accrete increases significantly in women with previous Caesarean sections. The incidence of placenta accrete is 1.18% among patients with placenta previa and 80% in patients with previous Caesarean section[15]. Furthermore, Caesarean section involves a higher cost than vaginal birth, and a government-funded healthcare system cannot advocate procedures with no tangible benefit. We encouraged trial of vaginal delivery, unless there is a clinical indication for Caesarean section. Women having normal vaginal delivery recover faster and have a shorter hospital stay, and this is associated with a higher breastfeeding rate and lower risk of maternal mortality[17].

In the present study, the lower rating of antenatal service in public hospital may be related to the discrepancy in the expectation of ultrasound service in routine antenatal follow-up. In our hospital, ultrasound service is provided to all registered pregnant women at 11 to 14 weeks of gestation for measuring nuchal translucency (as part of the Down syndrome screening test in first trimester), for determining the order of pregnancy, and for detecting major fetal structural anomalies and uterine or pelvic abnormalities. In later gestation, ultrasound service is provided to those with clinical indications only, owing to limited resource. Ultrasonographic measurement of fetal size does not reduce the incidence of small-for-gestational-age baby or improve perinatal outcome[18]. Contrarily, private hospitals offer ultrasound service at every antenatal visit to monitor fetal growth and serve the purpose of viewing baby and taking photos. Ultrasound service is an attractive proposition to pregnant women[19], probably owing to the visual confirmation of the reality of pregnancy, gaining reassurance about the well-being of the fetus, and a sense of 'meeting' the baby[20]. However, it may cause anxiety, shock, and disappointment when a scan shows a problem[21]. Furthermore, women may not understand well the diagnostic capabilities, limitations, and safety concern of the ultrasound[21,22].

This study has a few limitations. The questionnaire was not validated. Conducting the interview by telephone limits the length of the questionnaire and therefore questions are short and choices limited. However, for the question about reason for delivery at private hospital, only 12 (11.9%) women suggested other factors such as company benefit, relative being staff of the private hospital. Moreover, a pilot study showed that the questionnaire was easy for both participants and interviewer to understand and respond.

Conclusion

The overall rating to both public and private obstetric services in Hong Kong is good. 24.6% of women chose to delivery at private hospitals for reasons such as having designated doctor-in-charge, choice on mode of delivery, and safety issue. The Caesarean section rate was higher in women who chose to delivery at private hospitals. Further studies are warranted to investigate the reasons why these women prefer Caesarean delivery.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

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Appendix. Questionnaire

你好，我是東區尤德夫人那打素醫院婦產科醫生_____醫生/_____姑娘，現正在進行一個關於產科服務的意見問卷調查，目的是希望改善產前及產科服務，查看選擇產科服務的因素和評分。另外，我們會在醫院管理局電腦網絡提取閣下之前登記產前提交了的基本資料。是次蒐集的意見及所有資料絕對保密，完全出於自願性質。請問你願唔願意參加問卷調查?

1. 你的BB是在哪裡出生?
   ☐東區醫院 ☐私家醫院 ☐其他 (請註明)_____
2. BB是在多少週的時候出生?
3. 你是如何生BB的?
   ☐順產 ☐助產 (吸盤) ☐助產 (產鉗) ☐剖腹手術
4. 如是助產/剖腹，請説明其原因
5. 生產後，身體上有否特別問題出現?

   _____
6. 為何選擇在東區醫院/私家醫院生產?
   ☐方便 ☐經濟 ☐安全 ☐兒科配套 ☐可選擇醫生 ☐可選擇生產方式
   ☐可選擇醫院 ☐可選擇出生時間 (不適用於東區醫院生產女士) ☐其他
7. 為何也在東區醫院預約? (不適用於東區醫院生產女士)
   ☐方便 ☐經濟 ☐安全 ☐兒科配套 ☐其他
8. 請你就產前得到的服務給予一個評分。
   (最差) 1 2 3 4 5 (最好)
9. 請你就在產房時或生產的服務給予一個評分。
   (最差) 1 2 3 4 5 (最好)
10. 請你就產後得到的服務給予一個評分。
    (最差) 1 2 3 4 5 (最好)
11. 如果下次再懷孕，你會不會在同一間醫院生產?
    ☐會 ☐不會
    如不會，請註明原因_____
12. 對產科服務，其他意見。
13. 請問你有沒有餵人奶?
    ☐全人奶 ☐部分人奶 ☐沒有

謝謝您的寶貴意見！

Original Article

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Effect of frenotomy for tongue-tie on improving breastfeeding

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Introduction: Tongue-tie is a congenital anomaly that may hinder effective breastfeeding. This study aimed to review outcomes of frenotomy on breastfeeding in babies with tongue-tie and their mothers at a lactation clinic.
Methods: Since 2016, the lactation clinic of Department of Obstetrics and Gynaecology, Queen Elizabeth Hospital has taken a more active role to help babies with tongue-tie and breastfeeding difficulties. If feeding problems persisted, the babies were referred to a paediatric hospital for treatment. When indicated, frenotomy was suggested and performed upon consents using bipolar diathermy forceps under no anaesthesia. After frenotomy, the self-rated improvement on feeding condition was assessed in a scale of 0 (no improvement at all) to 10 (excellent improvement). At babies' 4 months of age, mothers were followed up by phone about feeding condition.
Results: From July 2016 to June 2018, 49 babies with tongue-tie and persistent breastfeeding problems were referred for consultation for frenotomy. Of them, four were deemed no need for frenotomy and were excluded, 36 underwent frenotomy and were categorised as the frenotomy group, and the remaining 9 who did not attend consultation or refuse surgery were categorised as the non-frenotomy group. In the frenotomy group, the most common breastfeeding difficulties was poor attachment (61.11%), followed by sore nipples (30.56%), ineffective suckling (5.56%), and poor weight gain (2.78%). After frenotomy, sore nipple was the most improved symptom with a mean rating of 8.18 (n=11), followed by poor attachment with a mean rating of 6.91 (n=22). In the non-frenotomy group, the most common breastfeeding difficulties was poor attachment (55.56%), followed by ineffective suckling (33.33%) and sore nipples (11.11%). At babies' 4 months of age, the proportion of mothers remaining direct breastfeeding was higher in the frenotomy group than the non-frenotomy group (80.56% vs 44.4%, p=0.028). Direct breastfeeding at 4 months was associated with frenotomy (87.88% vs 58.33%, p=0.028).
Conclusions: Frenotomy improved maternal nipple soreness during breastfeeding and the direct breastfeeding rate and duration.

Keywords: Ankyloglossia; Breast feeding

Introduction

Ankyloglossia (commonly known as tongue-tie) is a congenital anomaly characterised by an abnormally short, tight or thick lingual frenum attached near the tip of the tongue. It restricts tongue tip mobility and can cause poor breastfeeding and maternal nipple pain. It is present in 4% to 11% of newborns[1]. Frenotomy is commonly performed in Canada[2], Australia[3], and USA[4] to solve tongue-tie–related breastfeeding difficulties. Frenotomy is a simple surgical incision over the lingual frenulum using scissors, diathermy, or laser to release the restriction of tongue movement and enable more effective suckling.

In Hong Kong, healthcare professionals are increasingly aware of the impacts of tongue-tie on breastfeeding, but frenotomy remains uncommon and scarcely available. The aim of the present study was to review outcomes of frenotomy on breastfeeding in babies with tongue-tie and their mothers at a lactation clinic.

Methods

Since 2016, the lactation clinic of Department of Obstetrics and Gynaecology, Queen Elizabeth Hospital has taken a more active role to help babies with tongue-tie and breastfeeding difficulties. Newborns with suckling difficulties and their mothers were advised by a lactation consultant for breastfeeding attachment during hospital stay. Follow-up assessments were provided after discharge, and breastfeeding assistance and oro-motor training were applied accordingly. If feeding problems persisted, the babies were referred to a paediatric hospital for treatment. When indicated, frenotomy was suggested to the parents and performed upon their consents. Frenotomy was performed using bipolar diathermy forceps under no anaesthesia. At 1 week after frenotomy, the self-rated

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improvement on feeding condition was assessed in a scale of 0 (no improvement at all) to 10 (excellent improvement). All babies were followed up until feeding condition became stable. At babies' 4 months of age, mothers were followed up by phone about feeding condition.

The frenotomy group and non-frenotomy group were compared using the Fisher's exact test (if frequency was <5 in >25% of cells) or the Chi-square test for categorical variables and Mann-Whitney *U* test for continuous variables. A p value of <0.05 was considered statistically significant.

Results

From July 2016 to June 2018, 54 babies with tongue-tie and breastfeeding difficulties (including poor attachment/latch-on, persistent sore nipples, ineffective suckling, and poor weight gain) were referred to the lactation clinic. Among them, 28 were presented at 5 to 7 days of age, 21 at 8 to 14 days of age, and 5 after 2 weeks (2 of them were presented at 42 or 53 days of age when admitted to an infant ward owing to poor weight gain and feeding difficulty).

Of the 54 babies, four had a mild degree of short frenulum and exhibited no significant suckling problems, one was lost to follow-up, and the remaining 49 were referred to the paediatric hospital for tongue-tie treatment. Among these 49 babies, three did not attend consultation (who were deemed necessary for frenotomy by our lactation consultant) and 46 were assessed by paediatricians. Of the latter, four were deemed no need for frenotomy and were excluded from analysis. Of 42 babies recommended for frenotomy, 36 underwent frenotomy and were categorised as the frenotomy group, and parents of 6 babies refused to do so. These six babies and the three babies who did not attend consultation were categorised as the non-frenotomy group (Figure).

Tongue-tie was more prevalent in boys (n=31) than girls (n=14), with a male-to-female ratio of 2.2:1, which is similar to that reported in other studies[5-7]. The presentation at the lactation clinic was earlier in the non-frenotomy group than the frenotomy group (9.89 days vs 10.89 days, p=0.035, Table 1). The proportion of primiparous women was higher in the frenotomy group than the non-frenotomy group (91.67% vs 4.44%, p=0.004, Table 1). The mean age for frenotomy was 29.28±11.65 days (mode, 30 days; median [range], 27 [14-73] days).

In the frenotomy group, the most common breastfeeding difficulties was poor attachment (61.11%), followed by sore nipples (30.56%), ineffective suckling (5.56%), and poor weight gain (2.78%). In the non-frenotomy group, the most common breastfeeding difficulties was poor attachment (55.56%), followed by ineffective suckling (33.33%) and sore nipples (11.11%) [Table 1].

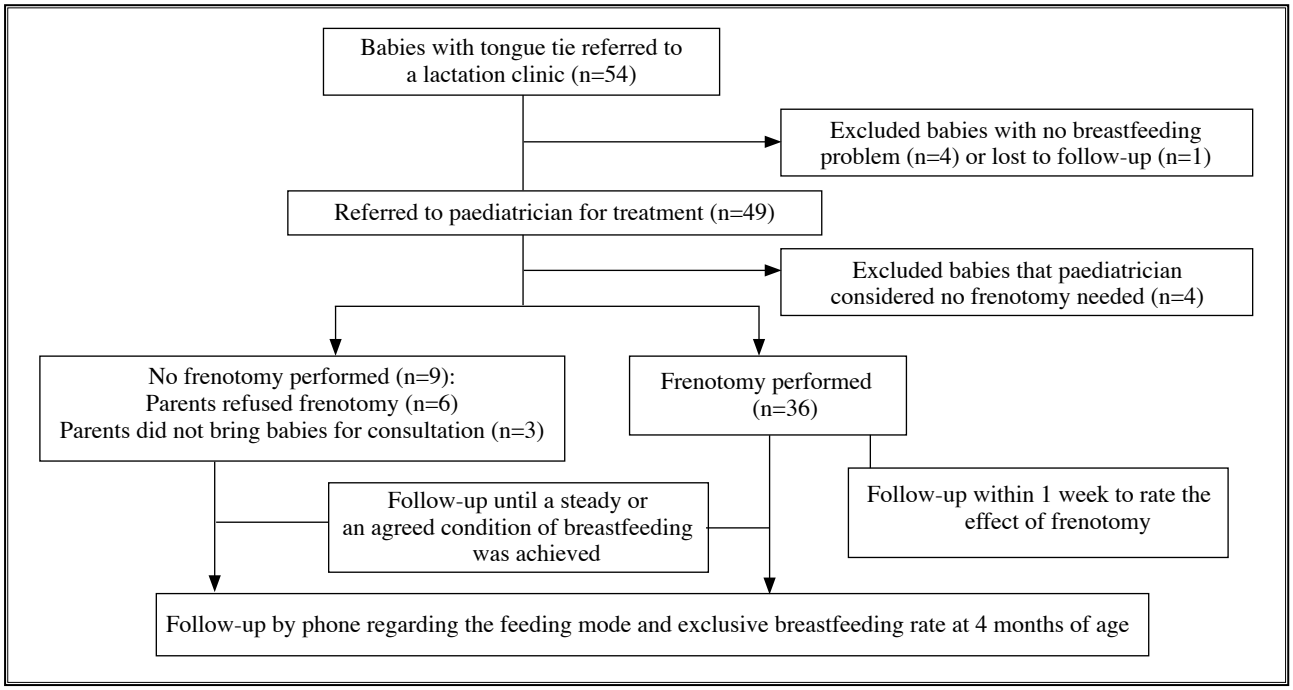

Figure: Flowchart of referral and follow-up of babies with tongue-tie

Table 1. Mother and baby demographics, breastfeeding difficulties, and feeding mode at 4 months

Variable	Frenotomy group (n=36)*	Non-frenotomy group (n=9)*	p Value
No. of male:female babies	27:9	4:5	0.08
Baby body weight, kg	3.07±0.35	3.02±0.39	0.71
Baby age at first presentation to lactation clinic, d	10.89±9.59	9.89±12.09	0.035
Baby age when frenotomy performed, d	29.28±11.65	-	-
Mother age, y	31.67±3.36	31.00±4.85	0.71
Parity			0.004
Primiparous	33 (91.67)	4 (44.44)	
Multiparous	3 (8.33)	5 (55.56)	
Mode of delivery			0.16
Vaginal delivery	25 (69.44)	4 (44.44)	
Caesarean section	11 (30.56)	5 (55.56)	
Working status			0.49
Working	28 (77.78)	6 (66.67)	
Non-working	8 (22.22)	3 (33.33)	
Breastfeeding difficulties			
Poor attachment	22 (61.11)	5 (55.56)	0.76
Sore nipples	11 (30.56)	1 (11.11)	0.238
Ineffective suckling	2 (5.56)	3 (33.33)	0.018
Poor weight gain	1 (2.78)	0 (0.00)	0.61
Feeding mode at 4 months			
Direct breastfeeding	29 (80.56)	4 (44.44)	0.028
Bottle breastmilk feeding	4 (11.11)	3 (33.33)	0.099
Non-breastfeeding	3 (8.33)	2 (22.22)	0.26
Direct exclusive breastfeeding			0.76
Yes	14 (38.89)	3 (33.33)	
No	22 (61.11)	6 (66.67)	

* Data are presented as mean ± standard deviation or No. (%) of cases

Regarding the effect of frenotomy on breastfeeding, sore nipple was the most improved symptom with a mean rating of 8.18 (n=11), followed by poor attachment with a mean rating of 6.91 (n=22) [Table 2].

Table 2. Maternal rating on improvement in breastfeeding difficulties after frenotomy

Breastfeeding difficulties	Maternal rating on improvement		
	Mean	Mode	Median (range)
Sore nipple (n=11)	8.18	10 (n=4)	8.00 (4-10)
Poor attachment (n=22)	6.91	10 (n=5)	7.50 (0-10)
Ineffective suckling (n=2)	3.50	-	3.50 (2-5)

At babies' 4 months of age, the proportion of mothers remaining direct breastfeeding was higher in the frenotomy group than the non-frenotomy group (80.56% vs 44.4%, p=0.028, Table 1). Direct breastfeeding at 4 months was associated with frenotomy (87.88% vs 58.33%, p=0.028, Table 3).

Discussion

Ultrasonographic studies on breastfeeding revealed that a flexible, extendable tongue is important in efficient removal of breastmilk[8-10]. Tongue-tie is associated with breastfeeding difficulties such as unable to latch-on, unstable suckling, fussy during breastfeeding, poor weight

Table 3. Comparison of direct breastfeeding at 4 months in relation to infant frenotomy and other maternal factors

Variable	Direct breastfeeding for >4 months (n=33)	Direct breastfeeding for <4 months (n=12)	p Value
Baby treated with frenotomy			0.028
Yes	29 (87.88)	7 (58.33)	
No	4 (12.12)	5 (41.67)	
Parity			0.91
Primiparous	27 (81.82)	10 (83.33)	
Multiparous	6 (16.98)	2 (16.67)	
Mode of delivery			0.61
Vaginal delivery	22 (66.67)	7 (58.33)	
Caesarean section	11 (33.33)	5 (41.67)	
Working woman			0.46
Yes	24 (72.73)	10 (83.33)	
No	9 (27.27)	2 (16.67)	

gain, nipple damage, low milk supply, and premature weaning of breastfeeding[11-13]. The need for frenotomy for infants experiencing breastfeeding difficulties has been highlighted[14-20].

In the present study, mothers who experienced sore nipples reported the highest rating on breastfeeding improvement after frenotomy. Frenotomy was reported to result in a real, immediate improvement in breastfeeding that was detectable by the mother and was well-sustained[14]. In a systemic review, frenotomy was reported to reduce breastfeeding mothers' nipple pain in the short term without serious complications, but there was no consistent positive effect on infant breastfeeding[21]. It is suggested that frenotomy may be considered for newborns with tongue-tie causing nipple pain in mothers.

In Hong Kong, the rate of breastfeeding has increased from 44.2% in 1997 to 87.5% in 2018, and the exclusive breastfeeding rate at 4 to 6 months has increased from 6% in 1997 to 29.1% in 2018[22]. The drop-out of breastfeeding in the first 2 months was the most significant. The primary reasons of breastfeeding cessation 1 month after delivery were reported to be suckling and latching problem (17.1%) and nipple and breast (9.0%)[23]. In the present study, the direct exclusive breastfeeding rate at 4 months of age was 38.89% in the frenotomy group, which is higher than the 29.1% reported in a breastfeeding survey of Hong Kong in 2017[22]. In addition, the breastfeeding rate (direct or bottle) at 4 months was 91.67% in the frenotomy group and 77.78% in the non-frenotomy group, which is higher than the Hong Kong average of 55.7%[22]. In 2017 in Hong Kong, the breastfeeding rate at birth was 87.5% but it decreased to 76.6% at the first month postpartum[22]. Mother's perseverance is crucial to successful breastfeeding. We advised mothers with breastfeeding problems to maintain the milk supply by regular milk expression, and to maintain the suckling ability of babies by using alternative feeding methods. Professional support, especially in the early postpartum period, can significantly improve the breastfeeding performance and duration[24,25]. In the present study, parents were explained that the sole aim of frenotomy was to resume effective direct breastfeeding, and that the present tongue-tie condition and frenotomy were not associated with speech development of babies. With this understanding, the parents' consideration for surgical intervention was focused on improving breastfeeding. Parents' acceptance for surgical intervention to improve breastfeeding was positive. Non-surgical treatments include craniosacral therapy, lactation intervention, and physical/occupational therapy on oral motor training or tongue stretching exercises[26,27].

One limitation of the present study is the small sample size. It is difficult to collect a larger number of cases for comparison. Referral was made based on the persistent breastfeeding difficulties despite initial feeding intervention. The analysis of improvement in breastfeeding difficulties after frenotomy was based on maternal perceptions and the proportion of direct breastfeeding.

Standardised clinical assessment tools (such as the Bristol Tongue Assessment Tool and the Hazelbaker Assessment Tool for Lingual Function[28]) should have been used for diagnosis and follow-up assessment. In the non-frenotomy group, improvement measures such as finger feeding and oro-motor training were applied, and follow-up sessions were stopped when the agreed breastfeeding status was achieved. No further analysis was carried out in this group.

Conclusion

Babies with breastfeeding problems (poor attachment and maternal sore nipples) should be checked for tongue-tie. When tongue-tie is identified as the leading cause for breastfeeding difficulties, early intervention should be provided. Frenotomy can improve attachment and suckling in breastfeeding. Meanwhile, mothers and babies also need support to maintain optimal breastfeeding. We recommend more training on assessment, non-surgical treatment, and frenotomy for tongue-tie be given to midwives, allied health professionals, and medical staff.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

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Maternal resuscitation drills for perimortem Caesarean section: use of a prepacked instrument set and a manikin model

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Prompt delivery of the baby by emergency perimortem Caesarean section (PMCS) in the event of maternal cardiac arrest is crucial for improving maternal and neonatal outcomes. Regular training and drills are essential to improve staff competence. We recommend the use of a prepacked set of instruments for PMCS and a manikin model for simulation training.

Introduction

Perimortem Caesarean section (PMCS) was originally performed as a religious ritual in Roman times to save the soul of the child from the womb of a dying mother through baptism and burial[1]. The unexpected benefits of neonatal or maternal survival were only recognised centuries afterwards. Maternal recovery and neonatal survival after PMCS was formally reported in the late 19th and early 20th centuries[2,3]. PMCS is now considered as a legitimate medical intervention during resuscitation of maternal cardiac arrest to improve maternal survival and save the baby.

Importance of perimortem Caesarean section

PMCS should be initiated within 4 minutes after maternal cardiac arrest for women with ≥20 weeks of gestation in order to relieve the aortocaval compression from the gravid uterus to increase maternal venous return and cardiac output[4]. PMCS can also help to decrease oxygen demand and improve pulmonary mechanics. A review of 38 cases of PMCS in 2005 reported that 34 fetuses survived and 13 of 20 mothers with reversible causes survived to time of discharge, and that there was no evidence of maternal deterioration after PMCS[5]. A review in 2012 reported a maternal survival rate of 54.3% (51/94) and no worsening of maternal status after PMCS[6]. Neonatal survival and neurologic outcome were related to the time between maternal death and delivery[6]. There is a consensus that PMCS should be performed promptly in order to improve maternal and neonatal outcomes.

Importance of training for perimortem Caesarean section

The incidence of maternal cardiac arrest in the peripartum period is around 2.8 to 3.6 per 100 000 pregnancies, and the incidence is found to be increasing in the recent decade[7,8]. This is postulated to be related to an increase in women with advanced maternal age and multiple pregnancies and thus an increase in pre-existing maternal medical disorders such as cardiac diseases. In Hong Kong, only two cases of pre-hospital maternal cardiac arrest treated with PMCS in the accident and emergency department have been reported[9,10]. Medical staff generally lack the experience of PMCS. However, prompt PMCS with ongoing effective maternal cardiopulmonary resuscitation can potentially improve maternal and neonatal outcomes. Therefore, practical training in maternal resuscitation and PMCS is crucial to both obstetrics and accident and emergency staff, and thus it has been included in the curriculum of obstetric emergency training courses[11]. The Society for Obstetric Anesthesia and Perinatology and the American Heart Association have each published a statement on maternal resuscitation for cardiac arrest in pregnancy[12,13]. Both have provided comprehensive guidelines and protocols on effective maternal resuscitation, as well as recommendations on clinical practice during the management of such emergencies. Flowcharts provided

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are precise and easy to follow, delineating the steps in managing maternal cardiac arrest. These guidelines are equally useful for team and skills training for real-life management, emphasising the need to perform manual left uterine displacement to relieve aortocaval compression until after delivery, and the need to proceed to PMCS if no return of spontaneous circulation after 4 minutes. A review on PMCS in 2014 outlined a succinct synopsis on practical PMCS procedures[14]. PMCS should be performed at the site of maternal cardiac arrest (for in-hospital cases). Consent for PMCS and urinary bladder drainage as well as strict sterility are not necessary. Midline incision may provide the quickest way to deliver the fetus. Individual units can use the above recommendations to work out their own workflow logistics and protocols. Simulation training can improve team training and enhance didactic teaching[15]. As effective management of maternal cardiac arrest inevitably involves various disciplines and specialties, simulation exercises have an important role to play. Maternal cardiac arrest drills should be held regularly in obstetric units in order to increase staff awareness, update staff knowledge, enhance team cooperation, and identify deficient areas.

Instruments for perimortem Caesarean section

Time should not be wasted for waiting availability of surgical equipment for PMCS[12]. The only mandatory instrument is a scalpel. We suggest using a disposable scalpel (which does not need to mount the blade onto the handle) to save the blade-mounting time and the time to find instruments (such as forceps or needle holders) to mount the blade, and to avoid sharps injuries during the mounting procedure. PMCS can be carried out more smoothly if a prepacked set of instruments are readily available, especially if surgical difficulties are encountered. The prepacked set of instruments should be stored in or near the resuscitation trolley in each obstetric unit and accident and emergency unit. The prepacked set contains a disposable scalpel, a bladder retractor, a pair of scissors, 2 metal clamps, 3 cord clamps, a kidney dish, a pack of antiseptic pour solution, and abdominal pads (Figure 1). Time should not be spent on lengthy antiseptic procedures; a very abbreviated antiseptic pour should suffice or the anti-septic step can be omitted[12]. An optional anti-septic pour solution is prepared, and it takes <5 seconds for the assistant to pour the solution. The abdominal pads are used to pack the uterine wound in case of bleeding after maternal circulation returns. The kidney dish enables safe placing of the scalpel, scissors, and metal clamps after use to avoid the risks of sharps injury to resuscitating staff after delivery of the baby while the maternal cardiac resuscitation continues.

Manikin model for perimortem Caesarean section

A manikin model that mimics human anatomy can help the staff to learn and perform the procedures more effectively. An inexpensive model for PMCS has been

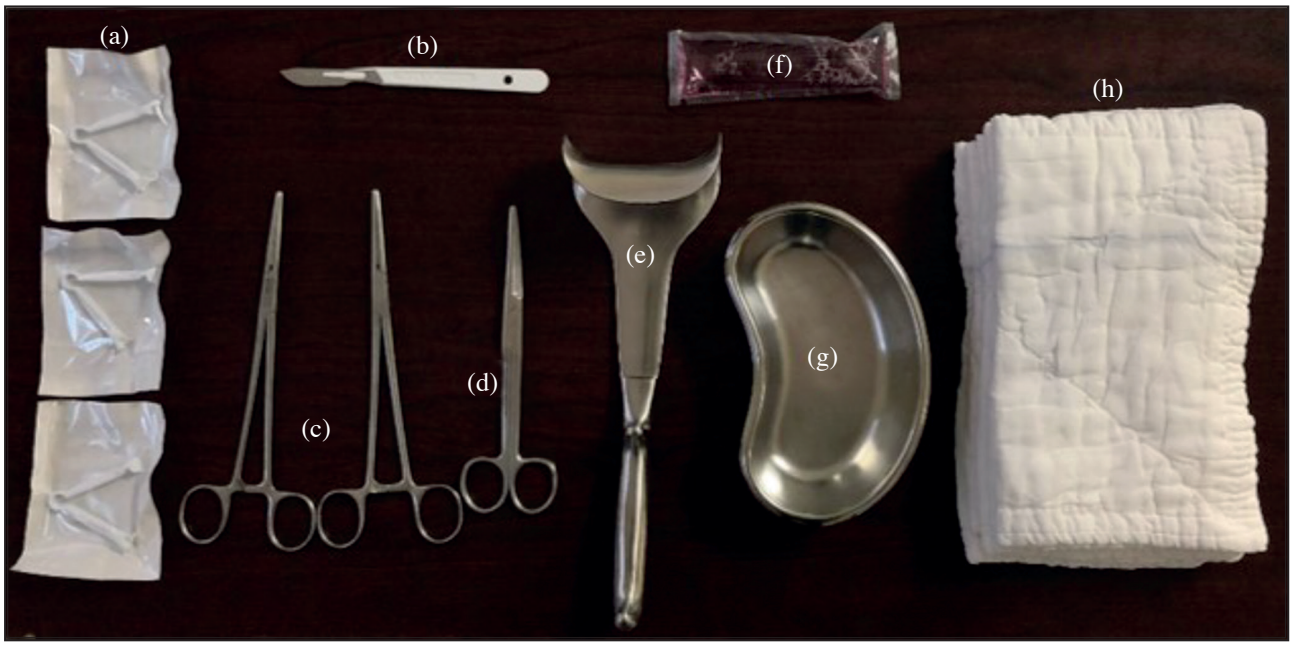

Figure 1. A prepacked set of instruments for perimortem Caesarean section: (a) cord clamps x3, (b) disposable scalpel, (c) metal clamps x2, (d) scissors, (e) bladder retractor, (f) antiseptic pour solution, (g) kidney dish, and (h) abdominal pads.

developed[16]. Training equipment is the most expensive component of emergency obstetric care training[17]. Therefore, an inexpensive replicable human anatomy training model is valuable for promoting PMCS simulation training. Our unit has developed a simple inexpensive manikin model for maternal cardiac arrest drills in 2019.

The model is constructed with a 28-cm diameter plastic beach ball, a latex glove, a baby manikin, a 0.5-inch-thick sponge mat, a transparent film, an adhesive tape, and a cable tie (Figure 2). A uterus filled with liquor with a fetus inside is assembled: the latex glove is filled with water with the end tied; the beach ball is trimmed to make an opening; a baby manikin is placed inside the beach ball and the water-filled glove is placed on top of the baby manikin inside the beach ball; and the opening of the beach ball is tied with the cable tie (Figure 3). The uterus is then wrapped with the sponge mat (as the abdominal wall), and the whole structure is secured on the abdomen of an adult manikin with adhesive tape and transparent film (Figure 4). A cross is marked on the position of the maternal umbilicus, and cardiotocographic sensors are attached on the abdomen to mimic continuous fetal heart rate monitoring during labour (Figure 5). During simulation training for PMCS, the abdomen and uterus are incised by the scalpel, and the leakage of water mimics liquor coming out (Figure 6). Videos demonstrating how the manikin model is made and how PMCS is simulated are available at the journal website (https://www.hkjgom.org).

Usefulness of the manikin model

The manikin model requires incision of several layers before the fetus is delivered. It mimics human anatomy from skin (transparent film), subcutaneous fat (sponge mat), uterine wall (beach ball) to amniotic membranes (surgical glove). This manikin model simulates the real-life procedure in which the fetus is not delivered by a single incision. This helps the staff to know the difficulties when PMCS is carried out while maternal cardiopulmonary resuscitation is simultaneously performed. The optimal positions for different members of the resuscitation team to take around the patient's bed should be practiced and ascertained. In our drill, the splash of liquor (from water-filled glove) on the floor after the PMCS can put the staff at risk of electric shock during cardiac defibrillation (when staff stepping on the wet floor). Therefore, the staff who performs the defibrillation should alert all staff to move away from the wet floor before pressing the defibrillation

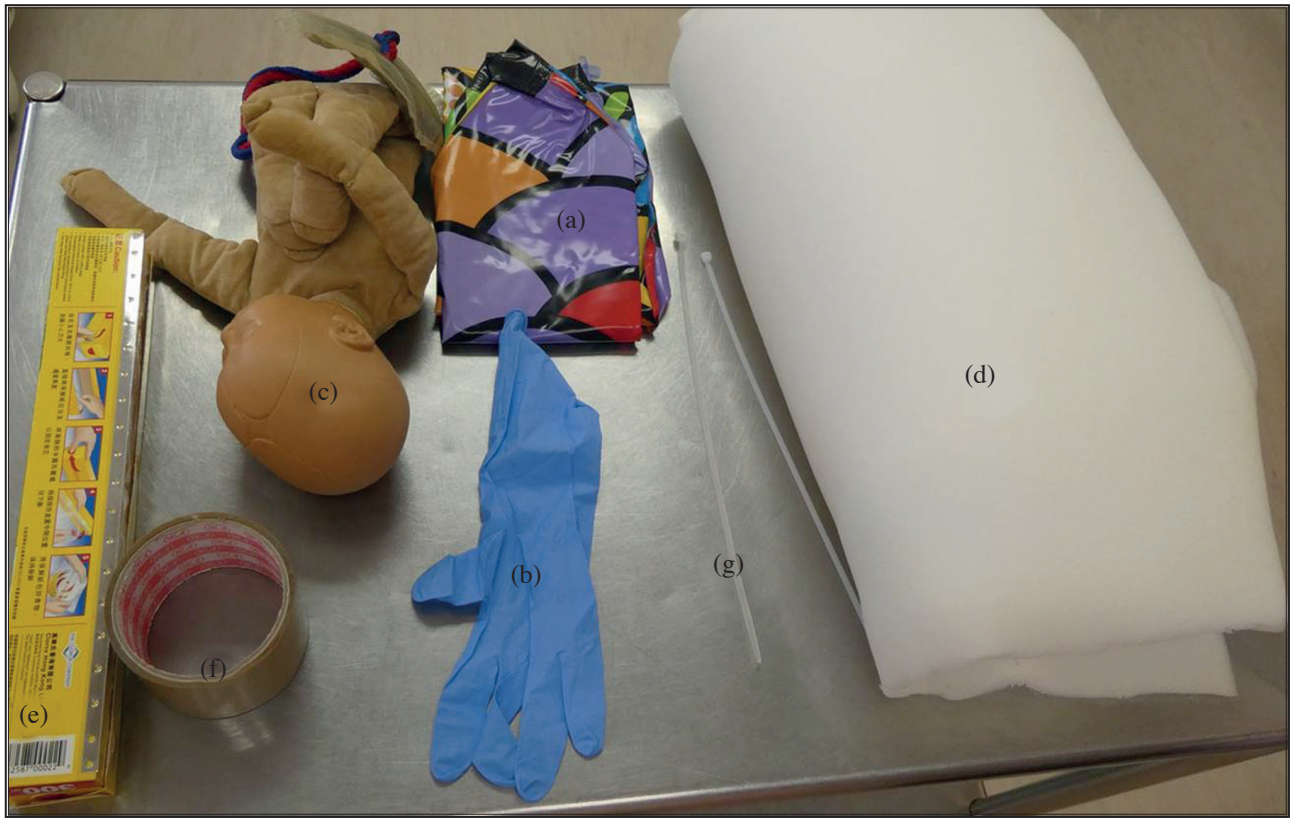

Figure 2. Materials for assembling a manikin model for perimortem Caesarean section: (a) 28-cm diameter beach ball, (b) latex glove, (c) baby manikin, (d) 0.5-inch-thick sponge mat, (e) transparent film, (f) adhesive tape, and (g) cable ties.

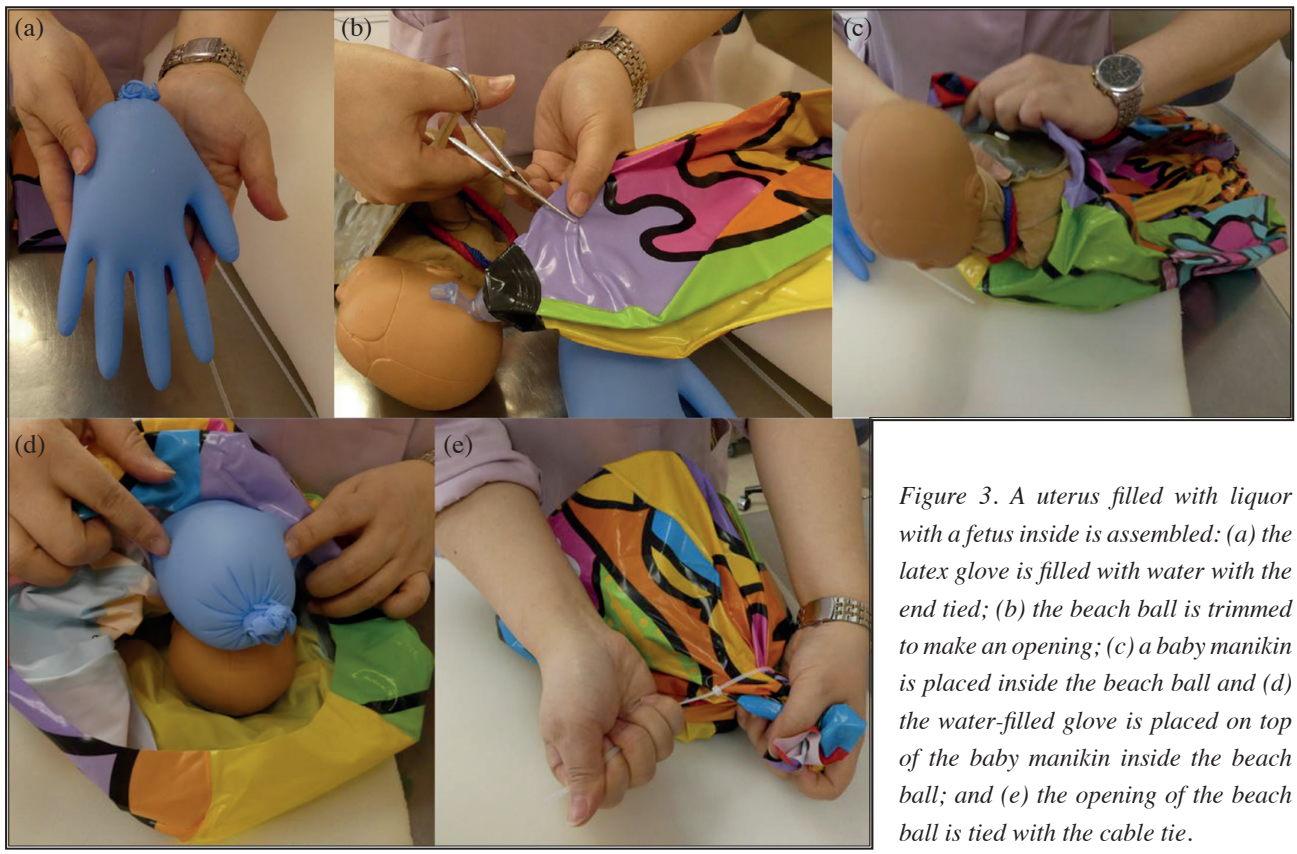

Figure 3. A uterus filled with liquor with a fetus inside is assembled: (a) the latex glove is filled with water with the end tied; (b) the beach ball is trimmed to make an opening; (c) a baby manikin is placed inside the beach ball and (d) the water-filled glove is placed on top of the baby manikin inside the beach ball; and (e) the opening of the beach ball is tied with the cable tie.

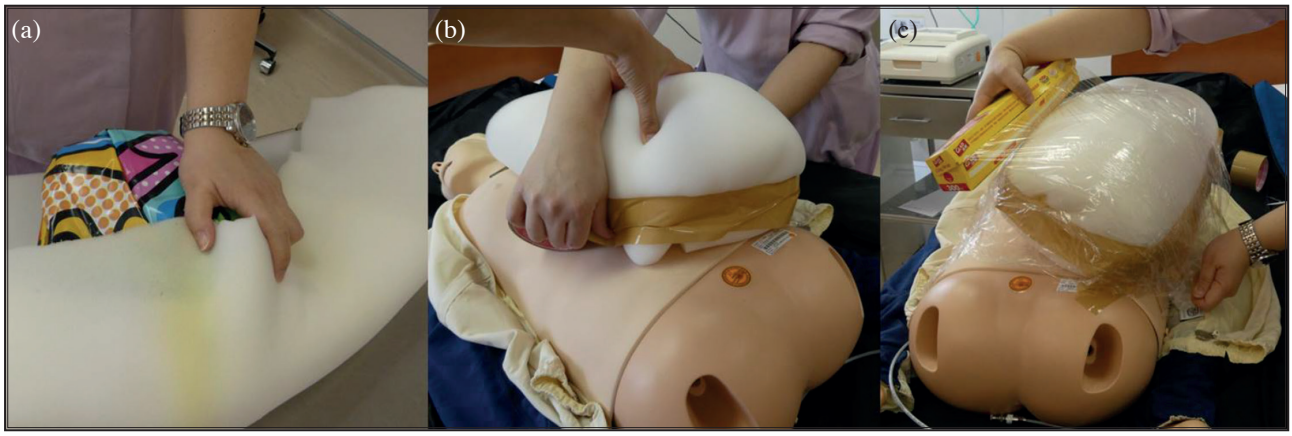

Figure 4. (a) The uterus is wrapped with the sponge mat (as the abdominal wall); (b) the whole structure is placed onto the abdomen of an adult manikin and (c) secured with adhesive tape and transparent film.

button. Indeed, if spare manpower is available, the floor should be dried with a towel or blanket after PMCS in order to avoid electric shock as well as slip and fall accidents. Although our model is primitive, many real-life issues during urgent resuscitation can be tested out. We have invited colleagues from other specialties (emergency medicine, anaesthesiology, paediatrics) to participate and observe. All found the manikin model very useful to help them to understand the procedure of PMCS and its role in maternal resuscitation.

Conclusion

Prompt delivery of the fetus by PMCS is crucial for improving maternal and neonatal outcomes. Training

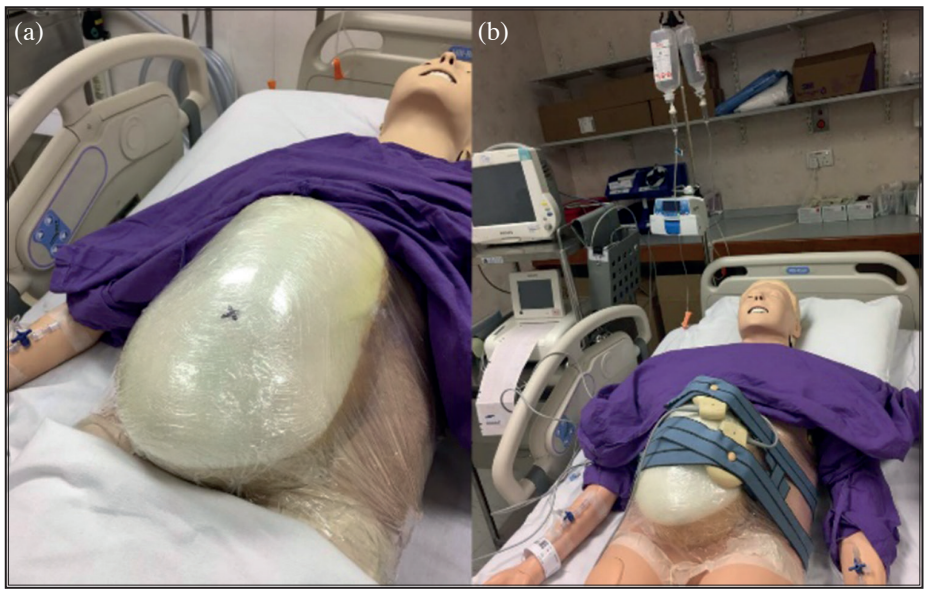

Figure 5. (a) A cross is marked on the position of the maternal umbilicus, and (b) cardiotocographic sensors are attached on the abdomen to mimic continuous fetal heart rate monitoring during labour.

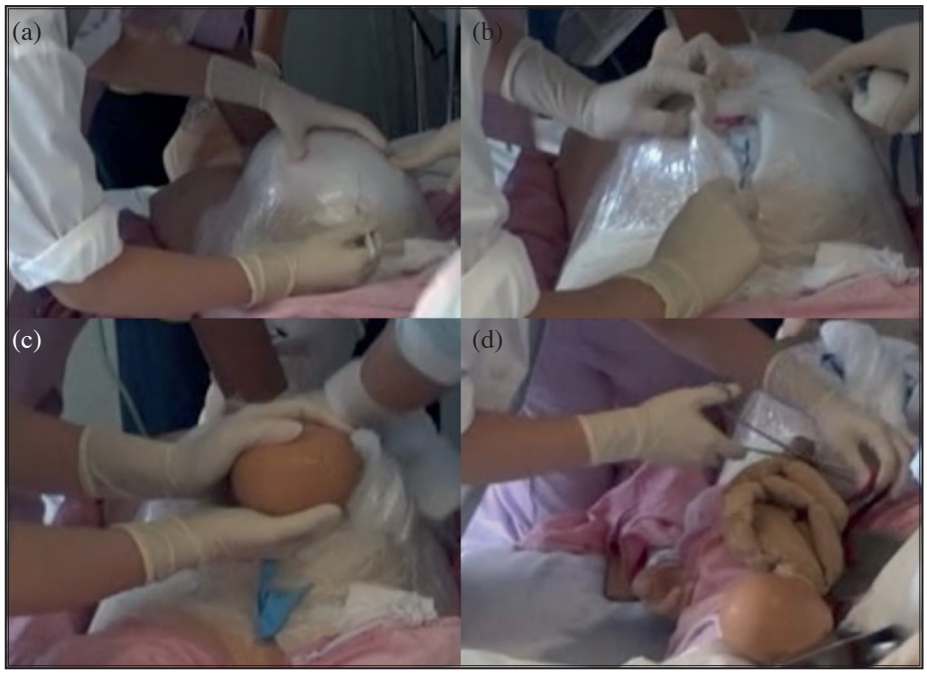

Figure 6. Perimortem Caesarean section is simulated: (a) the abdomen and (b) uterus are incised with the scalpel, and the leakage of water mimics liquor coming out. (c and d) The baby manikin is delivered.

and drills are crucial to improve staff competence and confidence to manage maternal cardiac arrest. A prepacked set of instruments for PMCS should be stored in appropriate wards in the obstetrics and accident and emergency departments. A simple and inexpensive manikin model is recommended for simulation training in PMCS.

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Ultrasonographic screening for fetal rib number anomalies

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Objective: To determine associations between fetal rib number anomalies detected on ultrasonography and chromosomal anomalies and other structural anomalies, and the outcome of affected pregnancies.
Methods: All cases of fetal rib number anomalies referred to the Prenatal Diagnosis Clinic of Queen Elizabeth Hospital between 1 January 2016 and 31 December 2019 were reviewed. Fetal ribs were examined by static three-dimensional multiplanar or volume contrast ultrasonography. Genetic counselling was offered. The prenatal and postnatal records were reviewed.
Results: 21 fetuses with rib number anomalies were identified over 4 years. The most common presentation was unilateral or bilateral absence of the 12th thoracic rib (n=12, 57.1%), followed by the presence of lumbar rib (n=6, 28.6%) and the presence of cervical rib (n=3, 14.3%). Three (14.3%) fetuses were identified to have anomalies in other systems: unilateral absence of nasal bone (n=1) and minor vascular anomalies (n=2). One patient with multiple anomalies of the fetus underwent amniocentesis, and the chromosomal microarray analysis was normal. Postnatally, 13 babies had chest radiographs taken. Two were confirmed to have normal number of ribs. Prenatal and postnatal findings were consistent in 6 (46.2%) babies.
Conclusion: Fetal rib number anomalies were an isolated finding in most cases. The prognosis is good in the absence of other major anomalies. The accuracy of prenatal ultrasonography appears to be low. These findings do not support routine counting of fetal rib number in second-trimester ultrasonography.

Keywords: Ribs; Ultrasonography, prenatal

Introduction

Human ribs can have a wide range of variations in the number, length, morphology, density, and fracture. Such abnormalities can be focal or generalised. Some can be isolated; others can be part of the pathological disorders including chromosomal or genetic disorders, syndromal disorders, metabolic diseases, bone dysplasias, and maternal drug exposure[1].

Visualisation of fetal ribs by two-dimensional ultrasonography is difficult owing to the spinal curvature and rib curvature. Three-dimensional (3D) ultrasonography improves visualisation of the spine and ribs by displaying the three orthogonal planes simultaneously on the coronal plane[2]. It improves the display of complex anatomy and is less operator dependent. Visualisation of the fetal ribs on 3D ultrasonography may help in the diagnosis of chromosomal or syndromal disorders such as the short rib polydactyly syndrome[3] and agenesis of the 12th rib with trisomy 21[4].

The incidence of fetal rib number anomalies ranges from 1% to 8%[1,5-7]. Rib number anomaly is the most common type of fetal rib anomalies, with supernumerary (cervical or lumbar ribs) and missing ribs accounting for 30% and 26% of all patterns, respectively[8]. International guidelines have recommended the practice to assess the curvature of the ribs in mid-trimester structural scan[9]. However, there is no recommendation on routine counting of fetal rib number. We have observed an increasing number of referrals for isolated fetal rib number anomalies in low-risk pregnant women. This is probably related to the increasing availability and application of 3D ultrasonography. Such findings induce anxiety of many parents. The present study aims to review cases of fetal rib number anomalies detected on ultrasonography, and to determine their association with chromosomal anomalies and other structural anomalies, and the outcome of the pregnancies. The findings are useful for determining the value of routine counting of fetal rib number as a part of standard procedure and to facilitate the management and counselling of the affected pregnancies.

Methods

This retrospective review was approved by the Kowloon Central / Kowloon East Cluster Research Ethics Committee (reference number: KC/KE-20-0028/ER-3). All cases of fetal rib number anomalies referred to the Prenatal Diagnosis Clinic of Queen Elizabeth Hospital between

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1 January 2016 and 31 December 2019 were reviewed. Data recorded included the source of referral, ultrasonographic findings (feasibility of assessment, fetal rib number), results of aneuploidy screening or invasive prenatal testing, and outcome of the babies.

Women were examined by maternal fetal medicine specialists after 20 weeks' gestation using a high-resolution ultrasonographic machine (Voluson E10, GE Healthcare, Wauwatosa [WI], USA) equipped with a volumetric abdominal transducer. The fetal spine was examined when the back was facing up and in the sagittal plane. A static 3D volume was obtained with a mechanical sweep when fetal movements were minimal. Fetal rib pattern and number were assessed using multiplanar reconstruction or volume contrast imaging or both (Figure).

Ultrasonographic and systemic examinations were performed to look for other structural abnormalities. All patients with fetal rib number anomalies were offered genetic counselling. The babies who delivered in our hospital were referred for postnatal examination by paediatricians, and chest radiographs were assessed by radiologists.

Results

In 2016, 2017, 2018, and 2019, there were 8435, 7591, 7903, and 7581 antenatal bookings in our units, respectively. We identified 21 (2, 1, 9, and 9, respectively) referrals for fetal rib number anomalies (Table 1). The incidence was 0.02%, 0.01%, 0.11%, and 0.12%, respectively. All 21 cases were singleton pregnancy. 20 (95.2%) patients were referred by private doctors, because fetal rib number was not routinely counted during mid-trimester structural scans in most public hospitals. One (4.8%) patient was referred by a midwife who had been trained to perform fetal anomaly scans. The most common presentation was unilateral or bilateral absence of the 12th thoracic rib (n=12, 57.1%), followed by the presence of lumbar rib (n=6, 28.6%) and the presence of cervical rib (n=3, 14.3%).

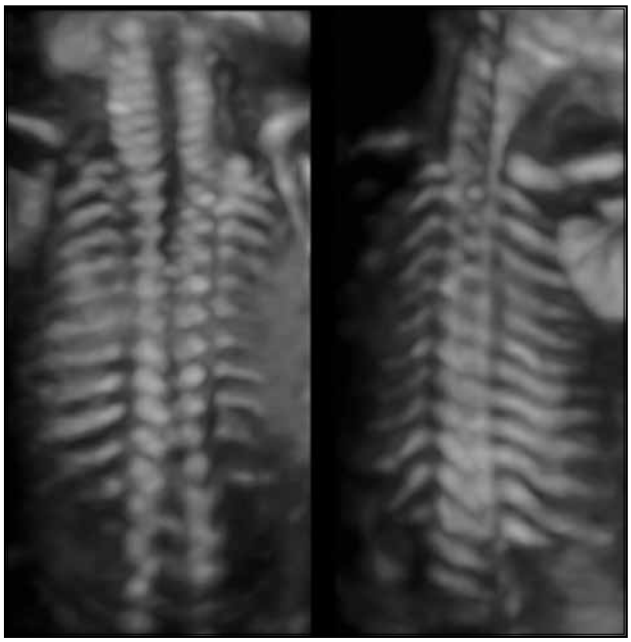

Figure. Volume contrast ultrasonographic images demonstrating normal number of ribs in a fetus

Visualisation of fetal ribs was successful in all 21 cases at 20 to 29 weeks' gestation, but visualisation was feasible in only 3 (18.8%) of 16 cases who were reassessed after 30 weeks' gestation.

Three (14.3%) fetuses were identified to have anomalies in other systems: unilateral absence of nasal bone (n=1) and minor vascular anomalies (n=2). One patient with multiple anomalies of the fetus underwent amniocentesis, and the chromosomal microarray analysis was normal. Others underwent combined first trimester screening (n=14), second trimester biochemical screening (n=1), and/or non-invasive prenatal screening (n=6) for Down syndrome. Results were all low risk.

All patients continued their pregnancies. 14 (66.7%) patients delivered in our unit with livebirths. Postnatally, 13 babies had chest radiographs taken. Only 2 were confirmed to have normal number of ribs. Prenatal and postnatal findings were consistent in 6 (46.2%) babies only. One baby with aberrant right subclavian artery and bovine aortic arch was found to have atrial septal defect; all other babies did not require further follow-up assessment.

Discussion

Ribs are developed from sclerotome cells in para-axial cells, which grow out from mesenchymal costal processes of the thoracic vertebrae[10]. The formation of ribs starts at 6 weeks' gestation and ossification takes place at 9 weeks[11]. The cells of the sclerotome are guided to their proper location by *homeobox (HOX)* gene and growth differentiation factor 11 *(GDF11)*[10]. Abnormal expression of *HOX* genes results in changing the positional identity of the vertebra[12]. This occurs more frequently at transitional zones between vertebral regions (cervico-thoracic and thoraco-lumbar boundaries), causing a change in the number of ribs[12]. Animal studies demonstrated significant effects of *GDF11* pro-peptide transgene on vertebral formation, which are likely occurring through depressing *GDF11* function and alternated locations of Hoxa-4 and Hoxa-5

Table 1. 21 cases of fetal rib number anomalies detected on ultrasonography

Maternal age, y	Rib number anomaly on ultrasonography			Pregnancy outcome	Postnatal radiography	Consistency of prenatal and postnatal imaging
	At <30 weeks' gestation	At ≥30 weeks' gestation	Other anomalies			
32	Lumbar rib, unilateral	Not visualised	No	Livebirth	Absence of 12th thoracic rib, bilateral	No
32	Absence of 12th thoracic rib, bilateral	-	No	Livebirth	Absence of 12th thoracic rib, bilateral	Yes
38	Cervical rib, unilateral	Not visualised	No	Livebirth	Cervical rib, unilateral	Yes
37	Lumbar rib, unilateral	-	No	-	-	-
34	Absence of 12th thoracic rib, unilateral	Not visualised	No	Livebirth	Normal	No
28	Absence of 12th thoracic rib, unilateral	Not visualised	No	Livebirth	Absence of 12th thoracic rib, bilateral	No
27	Absence of 12th thoracic rib, unilateral	Absence of 12th rib, bilateral	No	-	-	-
30	Absence of 12th thoracic rib, unilateral	Absence of 12th rib, unilateral	No	-	-	-
28	Absence of 12th thoracic rib, bilateral	Not visualised	Unilateral absence of nasal bone	Livebirth	Absence of 12th thoracic rib, bilateral	Yes
34	Absence of 12th thoracic rib, bilateral	Not visualised	No	-	-	-
32	Lumbar rib, bilateral	-	Aberrant right subclavian artery	-	-	-
35	Cervical rib, bilateral	Not visualised	No	Livebirth	Absence of 12th thoracic rib, bilateral	No
41	Absence of 12th thoracic rib, unilateral	Not visualised	No	Livebirth	Absence of 12th thoracic rib, unilateral	Yes
34	Cervical rib, bilateral	Not visualised	No	-	-	-
34	Lumbar rib, unilateral	Not visualised	No	Livebirth	Absence of 12th thoracic rib, unilateral	No
34	Absence of 12th thoracic rib, bilateral	-	Aberrant right subclavian artery and bovine aortic arch	Livebirth	Absence of 12th thoracic rib, bilateral	Yes
31	Lumbar rib, bilateral	Not visualised	No	Livebirth	Absence of 12th thoracic rib, unilateral	No
35	Absence of 12th thoracic rib, unilateral	-	No	-	-	-
32	Lumbar rib, bilateral	-	No	Livebirth	Normal	No
33	Absence of 12th thoracic rib, bilateral	Normal rib number	No	Livebirth	-	-
28	Absence of 12th thoracic rib, bilateral	Not visualised	No	Livebirth	Absence of 12th thoracic rib, bilateral	Yes

expression[13]. Experimental studies showed that altered expression of *Hoxa-4* and *Hoxa-5* genes result in formation of cervical ribs[13], whereas inactivation of *Hoxa-10* gene results in supernumerary lumbar ribs[14]. Over one-fifth of fetuses with cervical rib also had absent or rudimentary 12th rib, and this supports the theory of posterior homeotic shift[15]. Case reports of familial isolated cervical ribs suggest possible autosomal dominant inheritance[16,17].

The current recommendations for obtaining optimal ultrasonographic images of the ribs are based on expert opinions but are not validated by postnatal imaging. The 3D skeleton mode, multiplantar imaging, and volume contrast imaging are commonly used[5-7,18]. A small but significantly higher rate of satisfactory assessment of fetal ribs was reported at 21 to 23 weeks' gestation (97.37%-98.19%) than at 20 weeks' gestation (94.99%)[7]. The rate of fetal rib visualisation was higher at 20 to 27 weeks' gestation (100%) than at 14 to 19 weeks' gestation (82%)[19]. Minimal flexion of the fetal head is recommended[6,7]. The acquisition time is usually short (2 to 4 seconds per volume) to minimise the effect of fetal movements[5,6]. When volume contrast imaging is used, the maximum mode rendering is suggested to maximise the contrast between the bones and other tissues[5-7,18]. A thickness of volume contrast imaging of 15 to 20 mm was used in previous studies[5,18]. In multiplanar imaging, the region of interest is minimised to achieve clear and accurately rendered images[5,6]. Symmetrical appearance of ribs is preferred to compare the two sides and prevent acoustic shadowing[7,18].

Assessment of fetal ribs after 30 weeks' gestation has a low success rate. The reasons include unfavourable fetal position, lack of adequate amniotic fluid in front of the fetal spine, and relatively large fetal size resulting in difficulty to obtain an adequate volume for visualisation of the ribs. Visualisation of the first and second rib is more difficult in advanced gestation[6]. Reassessment of fetal ribs after 30 weeks' gestation does not yield additional findings to change the obstetric management.

To our knowledge, this is the first study that compares the prenatal ultrasonographic findings with the postnatal radiographic findings. Parents may not consent for postnatal radiographic examination owing to radiation exposure to their babies. In 7 of 13 babies, postnatal radiographic findings were inconsistent with prenatal ultrasonographic findings; rib numbers were underestimated or overestimated. Reasons for the inconsistency include delayed ossification of the ribs resulting in false impression of absent ribs, especially in early gestations; difficulty in identification of the first and second cervical ribs giving a false impression of absent ribs, especially in advanced gestation and when excessive flexion of the cervical spine[6]; and difficulty in identification of the correct vertebral level. It is difficult to determine the supernumerary ribs to be cervical or lumbar[7]. The correct vertebral level can be better ascertained by including the caudal or rostral end of the spine in the image, assuming that the number of vertebrae is correct. Multiple volumes may be required to visualise the entire fetal spine to determine the correct vertebral level. Gestational age should be taken into account in the interpretation of fetal rib anomalies. If the gestational age is <21 weeks, it is reasonable to repeat the scan before 30 weeks. Because of limitations of antenatal scanning, the need of postnatal radiological examination after birth should be included during antenatal counselling.

Absence of the 12th thoracic rib is the most common type of fetal rib number anomalies[5,6]. The selection against a change at the thoraco-lumbar boundary is much weaker than that against a change at cervico-thoracic one[20]. The incidence of other structural abnormalities has been estimated to be 18.2% to 46.7%[5,7,18], which is higher than the 14.3% in our study. Other associated systemic anomalies include cardiovascular, urinary tract, and neurological anomalies[5,7,18]. In our study, two of three fetuses with other anomalies had cardiovascular anomalies (aberrant right subclavian arteries). In cases of fetal rib number anomalies, a meticulous search for systemic anomalies is recommended[6]. However, the value of routine counting of fetal rib number in an otherwise structurally normal fetus is low when structural examination is routinely performed in the second-trimester ultrasonography[9].

Associations of aneuploidies or genetic syndromes with fetal rib number anomalies have been reported (Table 2)[21-30]. Around one-third of newborns with Down syndrome have 11 pairs of ribs on radiographs, and the incidence was six times higher than in those without aneuploidies[21]. Absence of the 12th thoracic rib occurs more frequently in those with free trisomy 21 (20.2%) than in those with translocation (9.1%) or mosaic trisomy 21 (0%)[4]. Significant reduction in the proliferation zones of chondrocytes results in rib aplasia in Down syndrome patients[31]. Lower than normal number of ribs is associated with trisomies 13 and 18[22]. In our study, none of the cases was found to have chromosomal abnormalities prenatally or postnatally. Our findings are consistent with more recent studies that report no associated chromosomal abnormalities[6,7]. This is probably related to the universal Down syndrome screening or non-invasive prenatal

Table 2. Associations of major fetal abnormalities with fetal rib number anomalies

Type of fetal rib number anomalies	Associated aneuploidies or genetic syndromes	Reference
11 pairs of ribs	Trisomy 21	Edwards et al[21], 1988
Reduced number of ribs	Trisomy 18, Trisomy 13	Achter et al[22], 2016; Ho et al[23], 1989
Absence of one rib	VATERL syndrome	Chen et al[24], 2012
10 pairs of ribs	Campomelic dysplasia	Basani et al[25], 2018
Absence of upper ribs	Poland syndrome	Ta et al[26], 2014
Cervical rib	Trisomy 21, Nail-patella syndrome, KBG syndrome, Simpson-Golabi- Behmel syndrome type 1	Furtado et al[27], 2011
	Monosomy X	Keeling et al[28], 1999
	Trisomy 9	Nakagawa et al[29], 2006
Lumbar ribs	Trisomy 8, Monosomy X, Cleidocranial dysplasia, Aarskog syndrome, Incontinentia pigmenti	Aly et al[30], 2016

screening, which enables early diagnosis in first or second trimester before fetal ribs can be clearly visualised. These findings suggest that routine counting of fetal rib number does not appear to have extra benefit in the diagnosis of Down syndrome in fetuses without other structural anomalies and with low-risk aneuploidy results.

Cervical rib was observed in over one-fourth of fetuses with monosomy X and hydrops and thus was considered a useful marker for evaluation of fetal hydrops. The presence of cervical rib is related to the altered function of *HOX* gene located in chromosome Xp22[28]. However, invasive prenatal testing is readily available to diagnose chromosome abnormalities in hydropic fetuses, irrespective of the presence of cervical rib. Although ossification centres of cervical ribs can be detected in radiographs earliest by 14 weeks' gestation, the timing of prenatal cervical rib detection has not been studied. This limits its value in early prenatal diagnosis. Moreover, it is technically difficult to visualise the skeleton in the neck region in the presence of nuchal oedema. It may be considered as a part of the assessment for hydropic fetuses after miscarriage or stillbirth where genetic diagnosis is not available.

Cervical ribs are regarded as markers of disadvantageous developmental events during morphogenesis that have been subjected to strong negative selection during evolution[20], and can be an independent predictor of stillbirth[27]. The prevalence of cervical ribs is almost 4 times higher in stillborn fetuses (43.1%) than liveborn infants who die in the first year of life (11.8%)[27]. The mortality rate of fetuses and neonates with cervical ribs is >70%[20]. The high incidence of major congenital anomalies in deceased fetuses and infants suggests that simple and pure presence of cervical ribs is not directly associated with fetal death, but it is related to other disadvantageous changes[20,27]. Routine prenatal screening of cervical ribs should not be used to predict fetal outcome in those without any associated anomalies.

Childhood cancer is associated with cervical rib anomalies[32,33]. *HOX* gene mutant may affect the tumour suppression and cause oncogenesis. A small but clinically significant higher prevalence of cervical ribs is reported in children with cancers, including neuroblastoma, brain tumour, leukaemia, soft tissue sarcoma, Wilms tumour, Ewing sarcoma, and germ cell tumour[32,33]. As the baseline risk of childhood cancer is very low (1.4 per 10 000 children in Hong Kong)[34], it is unlikely that cervical rib anomaly can be an effective marker for childhood malignancy.

Most patients with rib number anomalies do not have any symptoms, but clinical manifestations and complications can occur, depending on the type of anomaly. Up to 10% of individuals with a cervical rib may have thoracic outlet syndrome secondary to mechanical compression of the brachial plexus or subclavian artery by the cervical rib[35]. The type of manifestation depends on the morphology of the cervical rib, with incomplete ribs affecting only the brachial plexus and complete ribs affecting the subclavian artery as well[35]. Rare complications of thoracic syndrome include subclavian artery aneurysm[36,37] and cerebellar stroke in young patients[38,39]. Surgical removal may be required in symptomatic patients.

Most patients with isolated lumbar ribs or absent 12th thoracic ribs are asymptomatic, although pain in the

renal angle has been reported in those with lumbar ribs[40]. Presence of lumbar rib may hinder percutaneous renal biopsy through the renal angle between the 12th thoracic rib and lumbar vertebra[40]. Absence of the 12th thoracic rib may result in incorrect vertebral segment identification during lumbar intervention[41]. A rare case of lung herniation has been reported as a complication secondary to absence of multiple ribs[42].

The major limitations in the present study include the small sample size from a single centre and the retrospective nature. The true incidence of fetal rib number anomalies is underestimated because counting of fetal rib number is not routinely performed. The imaging modalities and techniques used for visualisation of fetal ribs varied with different operators and have yet to be standardised.

Conclusion

With adequate prenatal screening for aneuploidies and absence of other structural abnormalities, isolated fetal rib number anomalies have good prognosis. Detailed ultrasonographic evaluation is recommended owing to the increased risk of major structural anomalies. Invasive prenatal assessment should not be routinely offered for isolated fetal rib number anomalies with low-risk aneuploidy results and no structural abnormalities.

The value of routine counting of fetal rib number in structural scan in low-risk pregnancies remains uncertain. The low accuracy may create unnecessary anxiety to parents. Counselling should include the limitations of ultrasonographic assessment, possible complications/conditions associated with fetal rib number anomalies, the need of postnatal radiographic examination to confirm the diagnosis, and the need of systemic evaluation after birth.

Declaration

The authors have no conflict of interest to disclose.

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Cerebral venous sinus thrombosis in pregnancy: a case report

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We report a case of peripartum cerebral venous sinus thrombosis in a 33-year-old Chinese multiparous woman with 38 weeks of gestation and uneventful antenatal history who presented with a 3-day history of progressively worsening generalised headache. The woman later developed recurrent convulsions. After joint consultation with the neurologist, neurosurgeon, and anaesthetist, emergency Caesarean section under general anaesthesia was performed with perioperative anticonvulsant cover and postoperative anticoagulation therapy. A high index of clinical suspicion and multidisciplinary discussion are important for its timely management.

Keywords: Headache; Pregnancy; Seizure; Sinus thrombosis, intracranial

Case presentation

In August 2014, a 33-year-old Chinese multiparous woman with 38 weeks of gestation and uneventful antenatal history presented with a 3-day history of progressively worsening generalised headache. She reported no history of head injury, convulsions, or other symptoms suggestive of pre-eclampsia. Her blood pressure was 126/76 mm Hg and she had no albuminuria. Neurological examination results were unremarkable. Results of urgent blood tests for complete blood count, serum electrolytes, liver enzymes, urate and coagulation profile were all normal. The cardiotocogram was normal.

Urgent non-contrast computed tomography (CT) of the brain showed hyperdensities in the superior sagittal sinus and cortical vein (Figure 1). There was no midline shift or space-occupying lesion. The diagnosis of cerebral venous sinus thrombosis (CVST) was suspected. The on-call neurologist, neurosurgeon, and radiologist were consulted. Urgent CT venogram revealed a venous thrombosis involving superior sagittal, right transverse, and right sigmoid sinuses extending to the origin of right internal jugular vein (Figure 2). The woman later developed two episodes of generalised convulsions, and intravenous levetiracetam was given as anticonvulsant. Neurological examination results were normal. The fetal heart tracing was all along reactive. After joint consultation with the neurologist, neurosurgeon, and anaesthetist, emergency Caesarean section under general anaesthesia was performed with perioperative anticonvulsant cover and postoperative anticoagulation therapy. The operation was uncomplicated, with blood loss of 400 mL. A baby girl weighing 4.04 kg with good Apgar scores was delivered.

The woman was transferred to the intensive care unit for further management. She was prescribed subcutaneous low-molecular-weight heparin (LMWH) after haemostasis was ascertained. She recovered well and had no more convulsions or neurological deficits. On postoperative day 5, she requested to be managed in the private sector. A referral letter was issued about the peripartum events and the increased risk of venous thromboembolism in future pregnancy. She planned to use male condoms for contraception.

Discussion

CVST is rare and characterised by thrombosis of the dural sinuses and cerebral veins, causing venous congestion, cerebral oedema, haemorrhagic venous infarctions, and neuronal damages. In developed countries, its incidence is 11.6 per 100 000 pregnancies[1]. It is more common in the third trimester, and >75% of cases occur postpartum[2]. The increased risk of CVST in pregnancy is related to hypercoagulability and is higher in those with hypertension, advanced maternal age, Caesarean delivery, infections, or dehydration exacerbated by excess vomiting[3].

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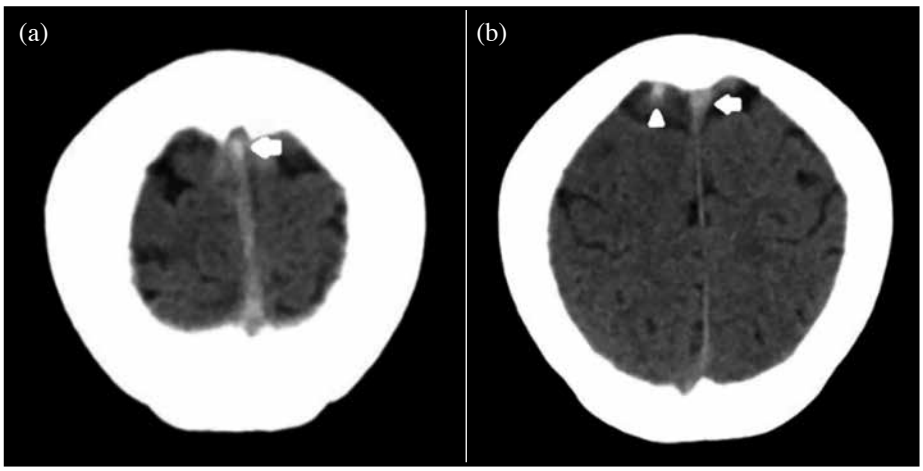

Figure 1. Non-contrast computed tomography of the brain showing hyperdensities at the superior sagittal sinus (arrows) and the cortical vein (arrowhead) suspicious of cerebral venous sinus thrombosis.

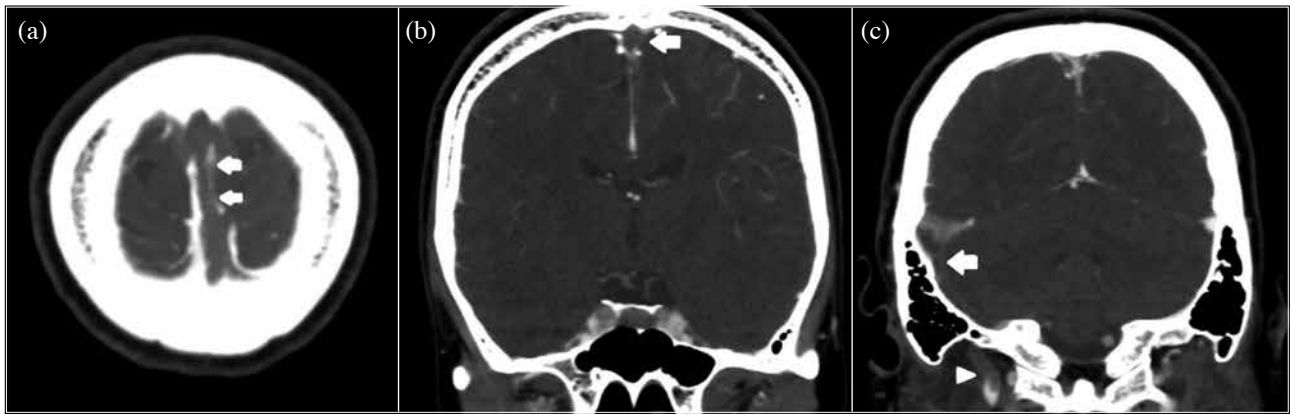

Figure 2. Computed tomographic venography showing filling defects at the (a and b) superior sagittal sinus, with the 'empty delta sign' (arrow) and (c) right transverse and right sigmoid (arrow) sinuses extending to the origin of the right internal jugular vein (arrowhead). The diagnosis of cerebral venous sinus thrombosis is confirmed.

The diagnosis of CVST requires a high degree of clinical suspicion owing to its rarity and variable clinical presentation. Headache is the most frequent symptom in CVST, but headache is a common complaint in pregnancy and postpartum period, and >90% of headaches are primary and benign and self-limiting without neurological sequalae[4]. Most patients with CVST present with a progressively diffuse headache, and 10% of them have an abrupt severe headache (as known as thunderclap headache). Headache could be the only presenting feature, but 10% of patients with CVST have no headache at all[2]. It is important to note that symptoms of CVST vary and can fluctuate over time, and that neurological deficits do not follow arterial distribution. Specific neurological presentation depends on the extent and location of venous thrombosis and its resultant complications. Other symptoms include dizziness, nausea, lethargy, visual loss, diplopia, and papilloedema. In a meta-analysis of observational studies, pregnancy is a significant factor associated with early-onset seizure (odds ratio [OR]=2.054)[5]. 40% of patients with CVST have focal or generalised seizures, which should alert physicians the need for further neuroimaging.[2]

Non-contrast CT are often negative, but it may demonstrate hyperdense thrombosed cortical veins or dural sinuses in a third of patients in the acute phase.[6] Ischaemic infarcts often undergo haemorrhagic transformation secondary to venous congestion and hypertension[2]. Parenchymal abnormalities such as cerebral oedema and haemorrhages may be seen most conspicuously on magnetic resonance imaging of the brain. Both CT venography and magnetic resonance venography (MRV) have comparable sensitivity for diagnosing CVST[7]. Nonetheless, there are concerns of radiation risk and drug safety, in addition to limited availability. For CT of the brain, as fetus is outside the field of view, the scattered radiation to the fetus is

negligible, and thus medical physicist consultation is not mandatory[8]. Contrast magnetic resonance venography is less preferable in pregnant women[8], as gadolinium-based contrast is considered as category C (ie, there are adverse effects on fetus in animal reproduction studies, but there are no controlled studies in humans), whereas iodinated contrast is considered as category B (ie, no adverse effects in animal reproductive studies, but there are no controlled studies in pregnant women). Non-contrast magnetic resonance venography using phase contrast or time-of-flight technique are feasible, but the results are sometimes inconclusive owing to artefacts.

Anticoagulation is the mainstay of treatment for CVST[7]. In a non-randomised study comparing patients receiving LMWH or unfractionated heparin, LMWH is associated with better functional independence after 6 months (adjusted OR=2.4) and fewer new intracerebral haemorrhages (adjusted OR=0.29)[9]. In a systemic review and meta-analysis, compared with unfractionated heparin, LMWH is recommended in the acute phase to reduce the mortality (OR=0.21)[10]. In the peripartum period, the optimal time to start anticoagulation requires balance between the thrombotic risk and bleeding risk during delivery and puerperium. The management for CVST in our patient with recurrent seizures was difficult. Discontinuation of anticoagulation is required before a scheduled delivery. Although seizures or epilepsy do not necessitate Caesarean delivery in general, the chance of recurrent seizure was high, and labour stress may increase the chance of convulsions compromising fetal well-being. Therefore, after multidisciplinary joint consultation, emergency Caesarean section was performed with perioperative anticonvulsant and postoperative anticoagulation when haemostasis was achieved.

Acute phase anticoagulation by LMWH, followed by oral anticoagulant for at least 3 to 12 months is recommended for patients with CVST[7]. The overall mortality rate of CVST was 2% to 10%, but the rate is significantly lower in pregnancy-associated cases[1,6]. According to the International Study on Cerebral Vein and Dural Sinus Thrombosis, most patients with CVST will have none (79%) to mild (8%) residual deficits after treatment[11]. Severe headache (14.1%), seizures (10.6%), and new thrombotic events (4.3%) are the most frequent complications during follow-up. Women with a history of CVST are advised against oestrogen-containing contraceptives. LMWH prophylaxis should be prescribed during subsequent pregnancies. Risks for recurrent CVST and non-cerebral venous thromboembolism in future pregnancies are reported to be 9 and 27 per 1000 pregnancies, respectively, compared with 0.116 and 1.72 per 1000 pregnancies in the general obstetric population[12]. Thrombophilia testing is recommended for women with thrombotic events in pregnancy and puerperium[13]. However regardless of thrombophilia abnormalities, they have a higher chance of adverse late obstetric events, including small-for-gestational age newborn, pre-eclampsia, eclampsia, HELLP syndrome (haemolysis, elevated liver enzymes, and a low platelet count), and placental abruption in their subsequent pregnancies, when compared with healthy women (19.2% to 24% vs 4%)[14,15]

Declaration

The authors have no conflict of interest to disclose.

Ethics approval

Ethics approval was obtained from New Territories West Cluster Research Ethics Committee (Ref: NTWC/REC/19097).

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Effect of endometrial thickness on pregnancy outcome in intrauterine insemination: a retrospective study

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Background: Intrauterine insemination (IUI) is a management option for infertility. We aimed to investigate the association between endometrial thickness (ET) and pregnancy outcome after IUI, and to identify factors affecting outcome in a Hong Kong population.
Methods: Medical records of women who underwent IUI at the infertility clinic of Queen Elizabeth Hospital from January 2013 to June 2019 were reviewed. Only the first cycle was included in the analysis to avoid over-representation of patients who failed treatment. Patients with or without clinical pregnancy were compared, as were patients with or without ongoing pregnancy. The predictive power of ET for pregnancy in IUI was assessed using the area under the receiver operating characteristic curve. Proportions of clinical pregnancy and ongoing pregnancy were calculated for 3 different subgroups of ET (<7 mm, 7-10 mm, and >10 mm).
Results: Of 337 IUI cycles, the clinical pregnancy rate was 12.7% (n=43); the ongoing pregnancy rate was 10.6% (n=36); and the multiple pregnancy rate was 1.4% (n=5). Shorter duration of infertility was associated with clinical pregnancy (2.67 years vs 3.51 years, p=0.003) and ongoing pregnancy (2.64 years vs 3.50 years, p=0.001). ET was not predictive of clinical pregnancy or ongoing pregnancy, with the area under the receiver operating characteristics curve being 0.473 and 0.509, respectively. Highest clinical and ongoing pregnancy rates occurred in those with ET of >10 mm. In patients with ET of >10 mm, all patients with clinical pregnancy successfully carried on to ongoing pregnancy.
Conclusion: ET is not predictive of IUI success. Longer duration of infertility adversely affects IUI outcome.

Keywords: Endometrium; Infertility; Insemination, artificial

Introduction

Intrauterine insemination (IUI) is a management option for infertility. Factors for favourable outcome include a younger age, a shorter duration of infertility, and a low body mass index (BMI).[1-3] Successful embryo implantation is related to endometrial receptiveness and thickness, which also are important factors for successful pregnancy[4]. Thin endometrium is associated with lower chance of conception, and conception is enhanced with increasing endometrial thickness (ET) in clomiphene citrate–induced IUI cycles[5]. For gonadotropin-stimulated cycles, ET of >8 mm is associated with a higher clinical pregnancy rate[6]. However, a meta-analysis of 23 studies has shown no association between ET and pregnancy rates in IUI with ovarian stimulation cycles[7]. A retrospective study investigating the effect of ET on 1065 gonadotropin-stimulated cycles also reported no significant difference between ET and reproductive outcome[8]; as did a prospective cohort study of 168 clomiphene citrate–stimulated IUI cycles[9].

In women with ovulatory disorders, ovarian stimulation with clomiphene citrate may result in lower ET than gonadotropin-stimulated cycles, but whether the lower ET causes the lower pregnancy rates is not clear[10]. The differences in ET among various ovarian stimulation agents are small and might be coincidental[7].

Most studies on the association between ET and IUI outcome are based on Caucasian populations. In this study, we aimed to investigate the association between ET and pregnancy outcome after IUI, and to identify factors affecting outcome in a Hong Kong population.

Materials and Methods

This study was approved by the Kowloon Central / Kowloon East Cluster Research Ethics Committee (reference no.: KC/KE-20-0031/ER-3). Medical records of women who underwent IUI at the infertility clinic of Queen Elizabeth Hospital from January 2013 to June 2019 were

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reviewed. Women who had undergone follicular tracking or used medication without insemination were excluded, as were those who aged >40 years, which is the upper age limit eligible for IUI in our hospital. Each woman could undergo a maximum of 3 cycles.

Patients were seen by the infertility team using standard department protocols[11]. For ovarian stimulation, in the first IUI cycle, 50 mg clomiphene citrate was used on days 3 to 7, whereas in subsequent cycles, injectable gonadotropin (menotropin or follitropin alfa) were used. Oestrogen level in blood was measured at day 3 of the cycle and before IUI. Follicles were tracked by transvaginal scanning using the Philips iU22 ultrasound machine. ET was measured on the sagittal plane of the uterus at the widest part. Ovulation was triggered by injection of human chorionic gonadotropin (hCG) when a single follicle reached 18 mm in diameter. IUI was performed 24 to 48 hours later. Cycles were cancelled in case of multiple follicle development, as defined by more than two follicles on ultrasound. Utrogestan pessary was given for luteal phase support. A urine pregnancy test was performed 14 days after IUI, and if positive, an ultrasound examination was performed to confirm pregnancy.

The primary outcome measure was clinical pregnancy, defined as positive urine pregnancy test and the presence of an intrauterine sac on ultrasound. Secondary outcome measure was ongoing pregnancy, defined as viable pregnancy progressing beyond 24 weeks of gestation.

Statistical analysis was performed using SPSS (Windows version 20.0; IBM Corp, Armonk [NY], US). A p value of <0.05 was considered statistically significant. Only the first cycle was included in the analysis to avoid over-representation of patients who failed treatment. Patients with or without clinical pregnancy were compared, as were patients with or without ongoing pregnancy. Categorical variables were compared using the Chi-square test, and continuous variables were compared using the Student's *t* test. The predictive power of ET for pregnancy in IUI was assessed using the area under the receiver operating characteristic curve. Proportions of clinical pregnancy and ongoing pregnancy were calculated for 3 different subgroups of ET (<7 mm, 7-10 mm, and >10 mm) based on the distribution of ET in our patients and previous studies[8,12,13].

Results

Of 635 IUI cycles performed in the study period, 8 were cancelled owing to poor or excessive response and 627 were performed in 337 patients. The clinical pregnancy rate was 11.8% (n=74); the ongoing pregnancy rate was 9.2% (n=58); and the multiple pregnancy rate was 1.9% (n=12). Six cases of ectopic pregnancy were excluded. To avoid over-representation of patients who failed treatment, only the first cycles were included for analysis (n=337). The clinical pregnancy rate was 12.7% (n=43); the ongoing pregnancy rate was 10.6% (n=36); and the multiple pregnancy rate was 1.4% (n=5). Patient characteristics per cycle and per patient are presented in Table 1.

Shorter duration of infertility was associated with clinical pregnancy (2.67 years vs 3.51 years, p=0.003) and ongoing pregnancy (2.64 years vs 3.50 years, p=0.001) [Table 2]. Other factors including patient age, partner age, BMI, number of cycles, primary or secondary infertility, cause of infertility, ET, follicle size, and oestrogen level were not associated with successful pregnancy.

ET was not predictive of clinical pregnancy or ongoing pregnancy, with the area under the receiver operating characteristics curve being 0.473 and 0.509, respectively (Figure 1).

Table 1. Patient characteristics per cycle and per patient

Patient characteristic	Per cycle (n=627)*	Per patient (n=337)*
Patient age, y	34.15 (25-40)	34.07 (25-39)
Partner age, y	36.98 (26-59)	36.83 (26-59)
Duration of infertility, y	3.55 (1-13)	3.40 (1-13)
Body mass index, kg/m^2	22.34 (15.79-36.20)	22.55 (15.79-36.20)
Oestrogen, pmol/L	2460.46 (64-10091)	2342.10 (64-10055)
Follicle size, mm	17.53 (14-25)	17.76 (14-25)
Endometrial thickness, mm	8.25 (2-18)	7.34 (2-18)

* Data are presented as mean (range)

Table 2. Associations of patient characteristics with clinical and ongoing pregnancy

Patient characteristic	Clinical pregnancy			Ongoing pregnancy		
	Success (n=43)*	Failure (n=294)*	p Value	Success (n=36)*	Failure (n=301)*	p Value
Patient age, y	33.72±3.254	34.12±3.180	0.441	33.64±2.987	34.12±3.212	0.390
Partner age, y	36.58±4.327	36.87±5.05	0.721	36.17±3.968	36.91±5.064	0.306
Body mass index, kg/m^2	22.53±3.702	22.55±3.872	0.972	22.51±3.929	22.558±3.841	0.942
Endometrial thickness, mm	7.19±2.762	7.36±2.698	0.699	7.47±2.843	7.32±2.69	0.748
Follicle size, mm	17.58±1.592	17.78±1.753	0.475	17.61±1.573	17.78±1.752	0.592
Oestrogen, pmol/L	2545.19±1198.47	2311.56±1720.60	0.391	2647.78±1194.487	2304.54±1708.539	0.243
Duration of infertility, y	2.67±1.52	3.51±2.27	0.003	2.64±1.291	3.50±2.272	0.001
No. of cycles			0.652			0.448
1	43 (58.1)			36 (62.1)		
2	18 (24.3)			13 (22.4)		
3	13 (17.6)			9 (15.5)		
Type of infertility			0.510			0.583
Primary	28 (65.1)			25 (69.4)		
Secondary	15 (34.9)			11 (30.6)		
Cause of infertility						
Male factor			0.321			0.123
Present	26 (60.5)			23 (63.9)		
Absent	17 (39.5)			13 (36.1)		
Anovulation			0.591			0.203
Yes	7 (16.3)			7 (19.4)		
No	36 (83.7)			29 (80.6)		
Unexplained			0.215			0.152
Yes	14 (32.6)			12 (33.3)		
No	29 (67.4)			24 (66.7)		

* Data are presented as mean ± standard deviation or No. (%) of patients

The distribution of ET was normal, ranging from 2 mm to 18 mm, with a peak at 6 mm (Figure 2a). Patients with clinical and ongoing pregnancy had ET of 3 mm to 13 mm. Patients were classified according to ET of <7 mm, 7-10 mm, or >10 mm. Highest clinical and ongoing pregnancy rates occurred in those with ET of >10 mm. The percentage of clinical pregnancy successfully becoming ongoing pregnancy increased with ET. In patients with ET of >10 mm, all patients with clinical pregnancy successfully carried on to ongoing pregnancy (Table 2b).

Discussion

In the present study, ET was not associated with clinical pregnancy after IUI. This finding is consistent with that reported in other studies[7-9]. The distribution of ET was normal, with highest clinical and ongoing pregnancy rate achieved in patients with ET of >10 mm. This finding echoes a study reporting that the highest pregnancy rate was associated with ET of 10-11 mm[1]. In addition, pregnancy rate increases with ascending ET and is highest when ET is between 10.5 mm and 13.9 mm, after which the success rate declines[8]. In the present study, the pregnancy rate was highest in women with ET of >10 mm, and no pregnancy occurred in women with ET of ≥14 mm. Extremes of ET could hinder the endometrial receptiveness, and very thick endometrium could be related to endometrial pathology, but this association was not found in the present study probably because of small sample size.

In the present study, longer duration of infertility was associated with lower chance of clinical and ongoing pregnancy in patients undergoing IUI. This finding is

similar to that reported in other studies[2,14,15]. The pregnancy rate is compromised when the duration of infertility is >3 years, independent of age, unless multifollicular ovarian response and a high sperm concentration are achieved[16]. Pregnancy rates are better if the duration of infertility is <6 years[2]. Thus, couples should seek medical attention for pregnancy earlier. For couples with longstanding infertility, counselling should be given about the reduced success rate.

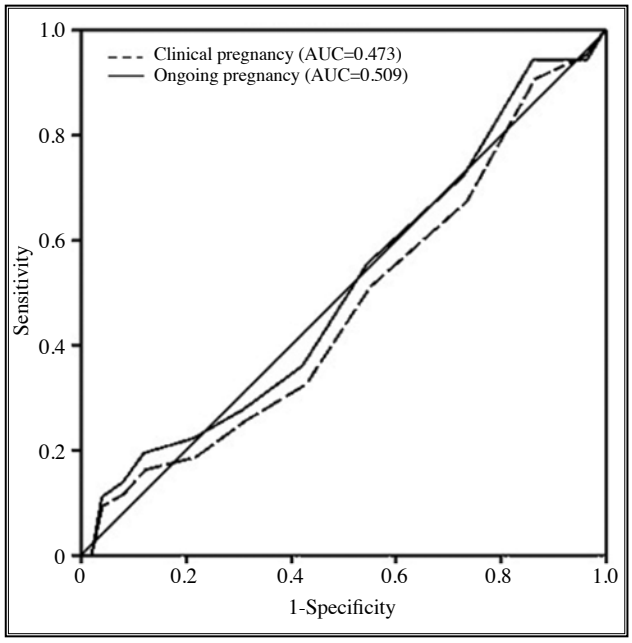

Figure 1. The area under the receiver operating characteristics curve for endometrial thickness was 0.473 for clinical pregnancy and 0.509 for ongoing pregnancy

Age is a well-known factor of infertility. Fertility decline accelerates after age 40 years[17]. The age-related decline in IUI success has been reported[3,8,18]. In the present study, age was not associated with IUI success. This may be due to exclusion of women aged >40 years and the small sample size.

Oestrogen level reflects ovarian reserve and growing of follicles and is associated with IUI outcome[8,18-20]. Peak oestrogen level is higher in successful cycles[8]. The peak oestrogen level and the number of follicles with a diameter >16 mm are significant factors for IUI success[18]. Younger women, shorter duration of infertility, and higher peak oestrogen level predict successful outcome in IUI[20]. In the present study, oestrogen level was not a significant factor for pregnancy, probably owing to the small sample size.

Peak oestrogen level and the number of follicles are also associated with multiple pregnancies[18]. Triplets

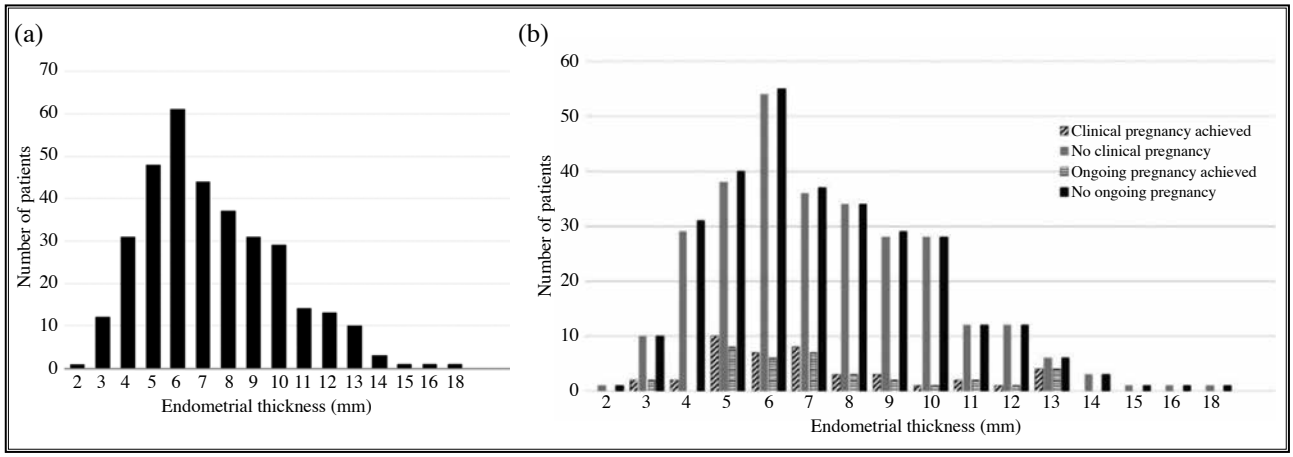

Figure 2. (a) Distribution of endometrial thickness and (b) distribution of endometrial thickness and clinical pregnancy

Table 3. Pregnancy outcome in different subgroups of endometrial thickness

Outcome	Endometrial thickness, mm		
	<7 (n=153)*	7-10 (n=141)*	>10 (n=43)*
Clinical pregnancy	21 (13.7)	15 (10.6)	7 (16.2)
Ongoing pregnancy	16 (10.4)	13 (9.2)	7 (16.2)
% of clinical pregnancy successfully becoming ongoing pregnancy	76.1	86.6	100

* Data are presented as No. (%) of patients unless otherwise stated

and higher order pregnancies are increased in higher peak oestrogen levels[21]. In the present study, there were only a few twin pregnancies, and cycles were cancelled in cases of multiple follicular development.

In the present study, primary or secondary infertility was not associated with IUI outcome. Women with secondary infertility have a higher pregnancy rate than women with primary infertility until the age 38 years[1]. The history of pregnancy is a predictor of pregnancy in IUI[22], but such an association is not found in another study[2].

Overweight or obesity is known to affect women in terms of infertility, anovulation, hormonal disturbance, and polycystic ovarian syndrome. Some studies reported that high BMI has a detrimental effect on the pregnancy rate[6,23], but other studies reported that high BMI does not affect the pregnancy rate[24,25]. In the present study, BMI was not associated with IUI success. This may be due to the fact that obese women (BMI >30 kg/m^2) only accounted for 8.9% of the sample. Obese or overweight women are advised to lose weight and maintain good health before IUI.

The study sample comprised Chinese and Southeast Asian populations. Patients were managed in the infertility clinic with standard protocol by a team of specialist doctors and nurses. Nonetheless, the present study is limited by the small sample size. Measurement of ET was performed by more than one clinician, and accuracy may be limited by the operator-dependent nature of ultrasound scans. In addition, different units in Hong Kong may have different protocols in ovarian stimulation and IUI, and the heterogeneity of protocol may hinder its generalisability and applicability.

Conclusion

Patients are advised to seek help from infertility services promptly, as longer duration of infertility adversely affects IUI outcome. In addition, ET is not predictive of IUI success; the use of medication to increase ET may not be helpful.

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Life-threatening bleeding secondary to adenomyosis: a case report

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Adenomyosis is a common benign gynaecological disorder. However, it may lead to life-threatening bleeding and complications. We report one such case in a 26-year-old woman who was complicated with disseminated intravascular coagulopathy, shock, and renal failure. She underwent emergency hysterectomy as a life-saving procedure.

Keywords: Adenomyosis; dysmenorrhoea; disseminated intravascular coagulopathy; shock

Case Presentation

In September 2017, a nulliparous 26-year-old woman presented to the accident and emergency department with severe dysmenorrhoea on the first day of her period. She had known history of adenomyosis complicated with menorrhagia and anaemia. At age 23 years, she had been admitted with menorrhagia and anaemia (haemoglobin level of 5.4 g/dL) and had undergone blood transfusion. Ultrasonography showed an enlarged uterus to 14 weeks' size with thickened posterior myometrial wall and cystic spaces in the endometrial cavity. Hysteroscopy showed a 4-cm endometrial polyp, which was confirmed to be benign after polypectomy. She was prescribed cyclical norethisterone but achieved suboptimal control, with multiple admissions for blood transfusions the same year. Injectable medroxyprogesterone acetate also failed to control the severe menorrhagia. In September 2015, she switched to combined oral contraceptive pills (ethinylestradiol and levonorgestrel).

On presentation, her menstrual flow was not heavy and there were no urinary or bowel symptoms. However, the patient was in shock a few hours after admission, with blood pressure decreased to 86/65 mm Hg, tachycardia (119 bpm), tachypnoea, and desaturation requiring 4L oxygen. There were diffuse rhonchi on respiratory examination. Abdominal examination revealed an enlarged uterus to 18 weeks' size. Chest radiograph showed bilateral diffused haziness (Figure 1). Transabdominal ultrasound showed the uterus enlarged to 18 weeks' size with cavity distended with an echogenic shadow measuring 7.92 cm × 8.36 cm, with negative Doppler flow. Both ovaries were not well seen, and there was no adnexal mass or free fluid. The initial diagnosis was adenomyosis with dysmenorrhea and shock with acute respiratory distress syndrome (ARDS).

The amount of vaginal bleeding was not accountable for her haemodynamic instability. Haemoglobin level decreased from 9.1 g/dL to 5.4 g/dL within a few hours. There were features of disseminated intravascular coagulopathy (DIC) with thrombocytopaenia (47 $\times 10^9$/L), and the clotting profile was markedly deranged to an international normalised ratio of 2.8, and the fibrinogen level was 0.3 g/L. She was given double inotropic support with dopamine and noradrenaline and was intubated in the intensive care unit. Transfusion with packed cells and platelet concentrates was started and fresh frozen plasma and cryoprecipitate given. After resuscitation, computer tomographic scanning showed an enlarged uterus of 20 weeks' size with a large haematoma measuring 11.9 × 8.8 × 10.7 cm in the endometrial cavity. There was intra-abdominal fluid with mild dependent density in the pelvis, which could be due to haemoperitoneum or infection. There were bilateral renal cortical necrosis and bilateral lung changes suggestive of ARDS (Figure 2).

In view of continuous drop of haemoglobin level and unstable haemodynamics, emergency hysterectomy and bilateral salpingectomy was performed. Intra-operatively the uterus was distended to 24 weeks in size, bluish, and oedematous; both fallopian tubes were oedematous. Blood loss was 2.85 L, and the patient required intra-operative transfusion of 7 units of packed cells, 8 units of platelet concentrate, 8 units of fresh frozen plasma, and 4 units of cryoprecipitate.

Pathology report showed the uterus weighing 1005 g. Section of the uterus showed foci of haemorrhage

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and congested blood vessels in myometrium. Foci of endometrial glands and stroma in myometrium consistent with adenomyosis.

Postoperatively, the patient was hospitalised for nearly 2 months. Shortly after operation, she developed acute renal failure (with serum creatinine level of 417 μmol/L) and required haemodialysis. She also developed persistent swinging fever. Computed tomographic scans showed an irregular pelvic collection with rim enhancement suggestive of infection. Fever was subsequently resolved after intravenous piperacillin/tazobactam and metronidazole. At postoperative 3 months, her renal function was on gradual recovery and no longer required haemodialysis. She was followed up half-yearly by renal physicians and her renal function was stable.

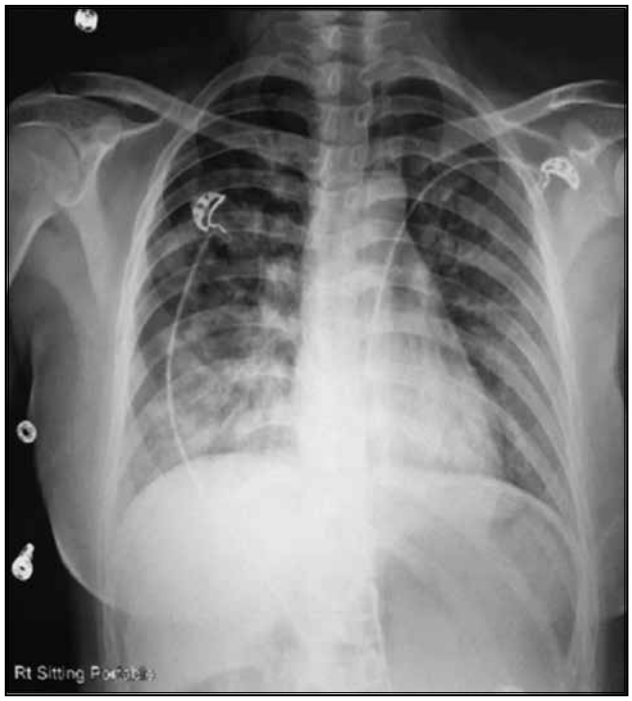

Figure 1. Chest radiograph showing bilateral diffuse haziness suggestive of acute respiratory distress syndrome.

Discussion

Adenomyosis is a benign condition characterised by the presence of ectopic endometrial tissues in the myometrium[1,2]. Patients usually present with dysmenorrhoea, menorrhagia, and anaemia. The diagnosis of adenomyosis requires histology confirmation. Ultrasonographic features suggestive of adenomyosis include echogenic nodules in the myometrium, myometrial thickening, enlarged globular uterus, and increased myometrial vascularity. The management strategy for adenomyosis is mainly symptomatic control. Definite treatment is hysterectomy.

The presentation of our patient is rare. There are few case reports in the literature on life-threatening presentation of adenomyosis. A case report from Taiwan described a patient who presented with exacerbation of menorrhagia and dysmenorrhoea and was later found to have adenomyosis-induced uterine rupture[3]. A case report from Japan described a patient with known adenomyosis who presented with menorrhagia and dysmenorrhea with blood picture showing DIC; she underwent anticoagulant therapy, and magnetic resonance imaging revealed spotty

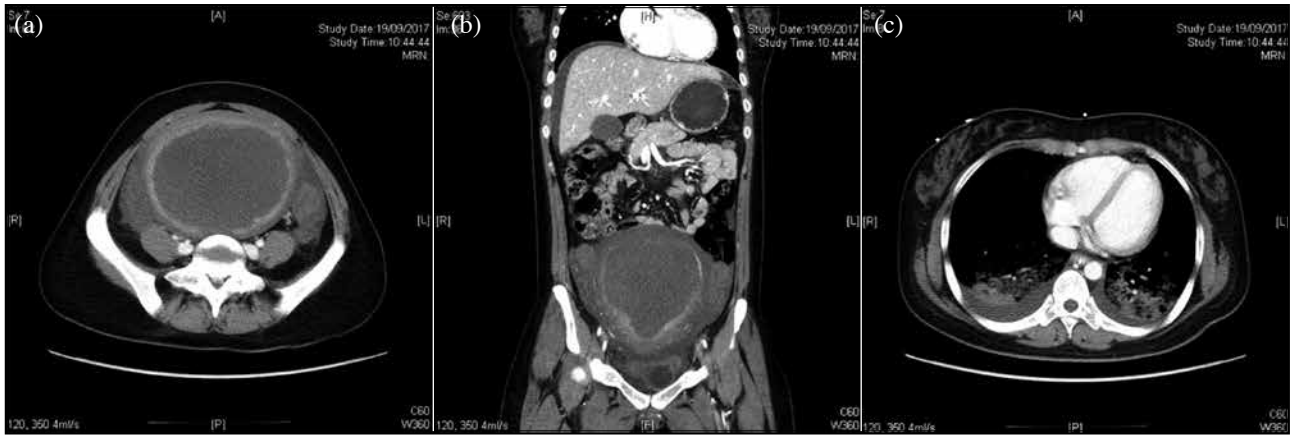

Figure 2. Contrast computed tomographic scans showing (a) an enlarged uterus with grossly distended endometrial cavity, (b) an enlarged uterus with distended cavity, and fluid in the peritoneal cavity in coronal view, and (c) bilateral lung bases with acute respiratory distress syndrome changes.

haemorrhagic lesions in the uterus[4]. A case report in Korea described a patient with known adenomyosis who presented with severe menorrhagia, dyspnoea, anaemia with DIC, and renal impairment; she was treated with hysterectomy and blood product transfusion[5].

It is postulated that ectopic endometrial tissues during menstruation may induce chronic inflammation, intramural haemorrhage, and tissue necrosis[1-3]. The coagulation cascade is activated with consumption of coagulation factors and leads to DIC. Haemorrhage associated with DIC further triggers the consumption of coagulation factors and leads to uncontrolled life-threatening bleeding. Bleeding occurs mainly within the myometrium, leading to the scenario similar to placental abruption[6]. Therefore, the uterus of our patient appeared grossly distended and bluish, like a Couvelaire uterus in placental abruption, but not much vaginal bleeding was observed.

Our case is unique in that the patient also developed ARDS, which was not reported in other case series. The underlying mechanism can be due to haemorrhagic shock, which rapidly induces pulmonary cytokine expression through an oxygen-radical dependent mechanism, leading to the development of widespread inflammation of the lungs and ARDS[7]. The present case is the extreme form of presentation of adenomyosis, and hopefully it can alert physicians that even benign condition can be life threatening.

Declaration

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Review Article

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Simulation training in obstetrics and gynaecology

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We review the development of simulation training and crew resource management in obstetrics and gynaecology. The current evidence was critically reviewed, and local experiences were summarised.

Keywords: Crew resource management, healthcare; Gynecology; Obstetrics; Patient safety; Simulation training; Teamwork

Introduction

Traditional clinical teaching in real-life settings has evolved towards specific skill-targeted and scenario-based simulation training in the past two decades. Because of rapid advancements in medical technology and surgical procedures, practising newly acquired skills on real patients becomes increasingly unacceptable owing to ethical and medicolegal concerns. Restrictions on doctors' working hours to minimise physician fatigue and enhance patient safety have adversely affected clinical experience and exposure. Trainees may not have the opportunity to encounter some rare but serious clinical conditions throughout their entire training programme. Nonetheless, they are expected to be competent once they achieve specialist status. Simulation training is a solution to these issues. It can take various forms: from skill-based training using part-task trainers and computerised virtual reality simulators on technical skills, to scenario-based team training on non-technical yet essential skills including communication and teamwork. Task-oriented exercise can be incorporated into clinical scenarios for more comprehensive team training in specified situations.

Theories for simulation training

The Adult Learning Theory[1] and the Experiential Learning Theory[2] are the endoskeleton of simulation-based education. Adult learning or andragogy is best achieved through experience and according to relevancy[1]. Adults are self-motivated and self-directed, and the accumulation of experiences affects their learning of new knowledge. Adults like to be and should be respected. Thus, at the beginning of a simulation training session, two ground rules are introduced to participants, namely, 'mistakes are puzzles to be solved but not crime to be punished' and 'everybody here is intelligent, well-trained, and eager to learn'[3]. Andragogy is the science of understanding (theory) and supporting (practice) lifelong education of adults[1].

Experiential Learning Theory suggests gaining new knowledge through a 4-stage learning cycle of concrete experience, reflective observation, abstract conceptualisation, and active experimentation[2].

In addition, fidelity is another important element to help learners invested into the scenario at simulation training. It is the degree of similarity between the training situation and the operational situation that is simulated. Fidelity is determined by environmental, equipment, and psychological elements; a combination of these creates a range of low to high fidelity[4,5]. Lower fidelity simulation is for new skill training for newcomers regardless of learner level, and for performance improvement for any level of learner. Higher fidelity simulation is for advanced learners, applying the real-world setting in high stakes test.

Skill-based simulation training

Skill-based simulation training in obstetrics has a long history. The earliest reference dated back to the ninth century, documenting the use of small wax or wooden figures to demonstrate childbirth. In the 18th century, a French midwife Madame du Coudray invented a life-size obstetrical mannequin made of fabric, leather, and sponges. She travelled throughout the French countryside with this part-task simulator to teach childbirth and demonstrate manoeuvres for managing birth-related complications[6]. Other part-task simulators for obstetric examinations and procedures include fetal scalp blood sampling[7], cervical dilatation assessment[8], ultrasound-guided amniocentesis[9], instrumental delivery[10], vaginal breech delivery[11], and shoulder dystocia manoeuvres[12].

Simple pelvic models have been used for training in pelvic examination and minor procedures such as endometrial biopsy, intra-uterine contraceptive device insertion, dilatation, and curettage. With the advent of

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gynaecological endoscopy, virtual reality system and haptic simulation model are introduced to facilitate this aspect of skills training[13-15].

In the past 2 decades, there has been rapid development in obstetrical and gynaecological simulators: from simple simulators for practising common surgical skills (eg, suturing) and obstetric procedures (eg, forceps delivery) to complex high-fidelity robot anthropomorphic female simulators for management of childbirth complications and virtual reality surgical systems for advanced laparoscopic procedures.

The Royal College of Obstetricians and Gynaecologists and the Royal College of Midwives regularly organise training workshops with simulation facilities for skills enhancement. Objective Structured Assessment of Technical Skills is an objective assessment tool utilising simulators for continuing assessment of trainees throughout their curriculum.

Crew resource management

In 1979, the National Aeronautics and Space Administration investigated the causation of a series of commercial airline crashes in 1970s, and human error was identified as the prevailing cause. This led to the development of crew resource management (CRM), a team-oriented concept aiming to reduce human error and improve safety. The Anaesthesia Crisis Resource Management[16] was one of the first efforts to transfer CRM to healthcare.

In 1999, the US Institute of Medicine published a report *To Err is Human: Building a Safer Health System* to examine the quality of healthcare in America[17]. Preventable medical errors were noted to result in high number of patient deaths. One recommendation was to implement patient safety programmes in healthcare organisations, which should "establish interdisciplinary team training programmes, such as simulation, that incorporate proven method of team management (as exemplified in aviation, where it is known as CRM)"[17].

In 2002, the obstetric department of the Beth Israel Deaconess Medical Center became the first obstetric unit in USA to apply CRM to clinical practice. This was triggered by a sentinel event in which a patient Suzanne had fetal loss and ruptured uterus necessitating hysterectomy following induction of labour[18]. Review of the case showed that clinical error, poor communication and teamwork contributed to the adverse outcome.

CRM is a cultural transformation at the workplace directed at patient safety and risk management[19]. Various 'toolboxes' are used to facilitate its application (Figure 1).

CRM places strong emphasis on communication and teamwork. The SBAR (situation, background, assessment, recommendation) technique, adopted from the military, enables brief, organised, and appropriate flow of information between professionals. It has become a form of standardised communication in CRM training. The UK National Health Service acknowledges the SBAR technique as an easy to use structured form of communication that enables information to be transferred accurately between individuals[20]. Other CRM tools including team briefing and debriefing, assertion, situational awareness, and decision making are also core elements to improve patient safety[21].

Scenario-based team training

Simulation training has evolved from individual skills training to scenario-based team training incorporated with the CRM principles for improved communication and teamwork. A joint statement on intrapartum patient care, endorsed by the American College of Obstetricians and Gynecologists and the American College of Nurse-Midwives, acknowledges the use of simulation and training in CRM to improve quality of care[22]. Numerous simulation training programmes have been developed, targeting at the obstetric care team, to enhance patient safety in the management of obstetric complications and emergencies.

The Advanced Life Support in Obstetrics course, organised by the American Academy of Family Physicians, is an inter-professional and multidisciplinary training programme for obstetric emergencies. It adopts a team-based approach involving obstetricians, midwives, and other members of the maternity care team[23]. The UK Managing Obstetric Emergencies and Trauma course is

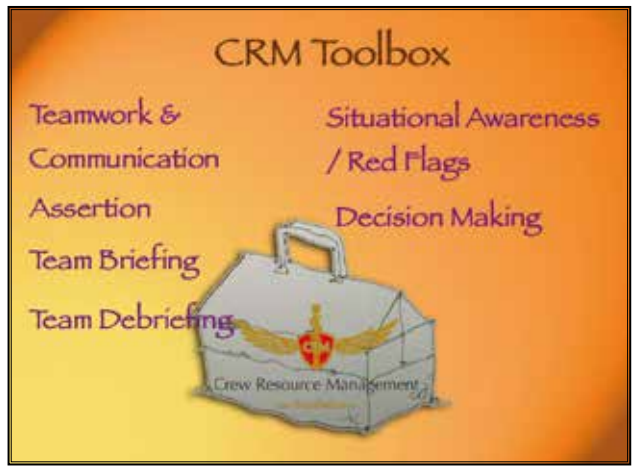

Figure 1. A crew resource management toolbox

a multidisciplinary scenario-and model-based training programme for obstetricians and midwives to enhance their clinical skills in handling obstetric emergencies[24]. The PRactical Obstetric Multi-Professional Training (PROMPT) course, provided by the PROMPT Maternity Foundation in UK, is an evidence-based training package for all members of the obstetric care team, including obstetricians, midwives, and anaesthetists, to enhance effective management of obstetric emergencies[25]. It is acknowledged by the Royal College of Obstetricians and Gynaecologists and the Royal College of Midwives. The Multidisciplinary Obstetric Simulated Emergency Scenarios course, developed at Barts and The London Medical Simulation Centre, aims to enhance nontechnical teamwork skills among multi-professional members of the maternity care team[26].

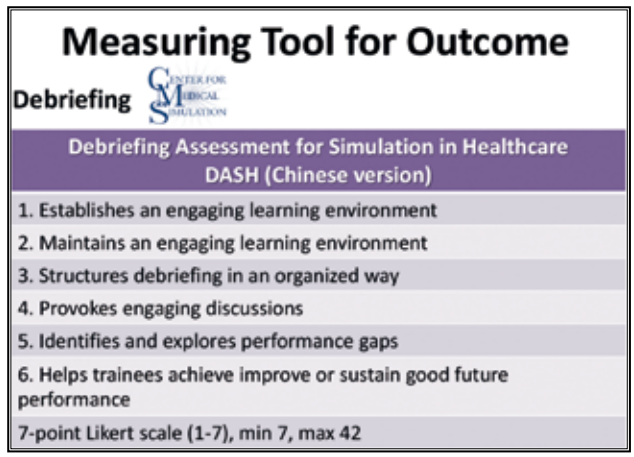

Figure 2. The Debriefing Assessment for Simulation in Healthcare

Different methods of simulation debriefing have been developed[27]. The Harvard debriefing model (debriefing with good judgment model) involves three phases: reaction, analysis, and summary[28]. Throughout the three phases, the instructor helps to determine the conceptual framework of the learner, provides respectful performance evaluation, and uses the advocacy-inquiry method to facilitate the learner to improve. The reaction phase allows for emotional decompression of all learners. Typically, this phase ends with a brief summary of the events and key issues for the objectives of the debrief to ensure every member is on the same page. The analysis phase can be achieved through learner self-assessment of what went well and what did not (the plus-delta method for feedback), directive feedback on specific behaviours, or focused facilitation using the advocacy-inquiry method. The summary phase reviews the objectives and summarises key learning points for take-home messages. When addressing specific teamwork skills, focusing on CRM concepts is often desirable, and visual aids such as posters or cards describing the tools and elements of CRM facilitate the summary phase.

Tools and checklists are available for evaluation and improvement of instructors through feedbacks. The Debriefing Assessment for Simulation in Healthcare[29] is an evaluation tool designed by the Center of Medical Simulation (Figure 2). It is a six-element behaviourally anchored rating scale with three versions: rater version (for trained raters to rate instructors), student version (for students to rate instructors), and instructor version (for instructors to rate themselves)[30].

Effectiveness of simulation training

The effectiveness of simulation training in obstetrics and gynaecology can be considered at four levels: acquisition of skills and knowledge, improvement in teamwork and CRM, identification of clinical errors and reduction of clinical risks, and impact on clinical outcome[31].

Most evidence on the acquisition of skills and knowledge was on obstetric emergencies, and the feedback was positive. After simulation training on shoulder dystocia, participants were more competent to perform manoeuvres to accomplish delivery. The successful delivery rate increased from 42.9% pre-training to 83.3% post-training ($p<0.001$)[12,32,33]. Compared with low-fidelity traditional device, high-fidelity mannequin was associated with a higher successful delivery rate (94% vs 72%, $p=0.002$), and a shorter head-to-body interval[12,32,33]. Total force applied was significantly lower after force perception training with high-fidelity mannequin. There was also better communication with patients (good communication rating increased from 57% to 83%) and improved documentation. After simulation training, participants were more likely to make accurate assessment (underestimation of blood loss in postpartum haemorrhage reduced from 49% to 32%)[34], to initiate proper treatment more promptly (shorter duration of 116 seconds to prescribe magnesium sulphate in eclampsia, $p=0.011$)[35], and to reduce the mean delivery time from 25 minutes to 14.5 minutes in cord prolapse[36]. Skill-based training also improved the participants' confidence in performing obstetric procedures such as forceps delivery and vaginal breech delivery, and the improvement sustained for at least 6 months after training[11]. Simulation training should be conducted at least annually for improved retention of the learned skills and knowledge[37,38].

Training with virtual reality system enables learning and practising surgical skills in a more real and pre-set critical rare situation with quicker setup[15]. The drawbacks

are the lack of haptic sensation and depth perception, and prolonged training of >1 hour may cause fatigue of the eye and neck muscles and result in headache[13,14,39]. A combination of virtual reality system ultrasound simulation and mannequin ultrasound simulation is reported to reduce the time of scanning on real patient by 20%[40].

Using validated multiple choice questions, there are inconsistent results towards knowledge improvement. A randomised controlled study showed an increased in score after training[41]. A small cohort study revealed that combining lecture-based teaching and simulation-based teaching resulted in most improvement (but not significant)[38]. Both skills and knowledge are proved to be improved by skill-based training.

A cross-sectional study to evaluate CRM intervention in improving teamwork and communications skills in the obstetric setting showed a positive change in the team and safety (odds ratio increased from 2.9 to 4.7) and a significant change ($p<0.05$) towards better knowledge of teamwork and shared decision making[42]. A prospective study on the effectiveness of CRM training and intervention on communication during Caesarean delivery showed a significant increase in quantity and quality of post-intervention communication between obstetric and neonatal teams[43].

The American College of Obstetricians and Gynecologists Quality Improvement and Patient Safety Committee developed weighted scores for outcome measures to evaluate the quality of obstetric care: the Adverse Outcome Index, the Weighted Adverse Outcome Score, and the Severity Index. In the Beth Israel Deaconess Medical Center, CRM implementation resulted in a reduction of the Adverse Outcome Index from 5.9% to 4.6%, representing a 23% decrease in adverse obstetric events, whereas the Weighted Adverse Outcome Score and the Severity Index also decreased by 33% and 16%, respectively[44]. Hospital-wide Safety Attitude Questionnaire showed that after CRM implementation labour and delivery staff had more positive attitude about the unit's safety than the rest of the hospital[45].

A multicentre randomised control trial to evaluate the effect of obstetric team training on team performance and medical technical skills concluded that team performance measured by the validated Clinical Teamwork Scale improved after training (7.5 vs 6.0, $p=0.014$), and that utilisation of appropriate medical technical skill was more frequent in the training group (83% vs 46%, $p=0.009$)[46].

From risk management perspective, team-based training can effectively identify system errors and reduce clinical risks with decrease in subsequent litigation[47]. Team training with CRM concepts helps address common errors such as delay in transport to the operating room, lack of familiarity with medications for obstetric haemorrhage, poor technique in cardiopulmonary resuscitation, and inadequate documentation in shoulder dystocia. CRM implementation in a maternal care team resulted in a reduction in the number of obstetric malpractice lawsuits and claims, with a 62% decrease in the number of high-severity adverse event claims[44]. Some insurance institutions have made simulation team training and assessment a mandatory requirement for malpractice cover.

Although there is evidence on improvement in skills, confidence, and teamwork of obstetric staff after simulation training, it is unclear whether this can translate to improvement in clinical outcome. A retrospective cohort observational study in the Southmead Hospital demonstrated a positive effect of an obstetric emergency training programme on neonatal outcome. The training programme consisted of lectures, small group discussions, and a series of obstetric emergency drill stations. There was a significant reduction in low 5-minute Apgar score (≥ 6) from 86.6 to 44.6 per 10000 births ($p<0.001$, relative risk=0.51) and in hypoxic ischaemic encephalopathy from 27.3 to 13.6 per 10000 births ($p=0.032$, relative risk=0.50)[25]. This improvement in neonatal outcome could sustain over time as training continued. This positive experience contributed to the development of the PROMPT train-the-trainer course. Another study by the Southmead Hospital on shoulder dystocia training showed a significant reduction in neonatal injury, mostly brachial plexus injury, following shoulder dystocia delivery (pre-training 9.2% to post-training 2.3%, relative risk=0.25), and non-significant reduction in neonatal fracture and low 5-minute Apgar score[48]. The introduction of the PROMPT course to the Mpilo Central Hospital in Zimbabwe led to a 34% reduction in maternal mortality (pre-training 0.74% to post-training 0.49%)[49].

Nonetheless, one study demonstrated a significant reduction in the Adverse Outcome Index following the implementation of a CRM training course augmented with high-fidelity medical simulation[50]. A multicentre randomised control trial concluded that team training with the MedTeams Labor and Delivery Team Coordination Course (with CRM-based principles and a curriculum used in hospital emergency and obstetrics departments) did not result in improvement in the Adverse Outcome Index[51].

In a review of outcomes of emergency obstetric simulation training, maternal and fetal outcomes remained unchanged despite a significant shortening of the duration to initiate obstetric cardiopulmonary resuscitation and to perform perimortem Caesarean section[52]. The significant reduction in median time to delivery for umbilical cord prolapse after simulation training did not result in improved neonatal outcome[52]. Apart from the Southmead Hospital experience[25,53], other studies on shoulder dystocia simulation training revealed no significant improvement in maternal and neonatal outcome despite increased awareness and early recognition of the condition[48,54]. One reason for this inconsistency is that the rarity of the obstetric emergencies may render post-training change in clinical outcome statistically insignificant.

Local experience

In Hong Kong, simple obstetric models have been used in the training of trainee doctors and midwives. Simulators have been used in laparoscopic skill training since the early 1990s. It is an integral part of the intermediate level laparoscopic workshop organised by the Hospital Authority Training Subcommittee in Obstetrics and Gynaecology for all trainees in Hong Kong. The Advanced Life Support in Obstetrics course has been regularly run in Hong Kong since 2003, and it is jointly organised by the Hong Kong College of Emergency Medicine and the Hong Kong College of Obstetricians and Gynaecologists.

Team-based simulation training has been implemented at varying paces for different medical specialties, with anaesthesiology and emergency medicine being the forerunners. The Hong Kong Society for Simulation in Healthcare was formed in 2013 to promote healthcare simulation-based education. With affiliation to the Center of Medical Simulation in Boston, the Hong Kong Jockey Club Innovative Learning Centre for Medicine within the Hong Kong Academy of Medicine was opened in late 2013. Its position statement on simulation-based training recognised the potential of simulation to add significant value to postgraduate medical education, and endorsed its integration into current training curricula. It organises regular courses on simulation-based learning, and it is equipped with a variety of endoscopic and laparoscopic simulators, part-task trainers, and location-specific training rooms for scenario-based training.

In 2009, the Hospital Authority commissioned the Pamela Youde Nethersole Eastern Hospital to pilot CRM training, aiming at organisational cultural change at all levels and across disciplines to improve patient safety. In collaboration with an American healthcare consultancy organisation, train-the-trainer workshops were held and a classroom training programme tailored to the local situation was designed[55]. Around 3000 staff of the Hong Kong East Cluster were trained from 2009 to 2012. Evaluation of training effectiveness showed encouraging results, with improvement in 11 out of 12 dimensions of safety culture as delineated by the Agency for Healthcare Research and Quality in the post-training survey[56].

This prompted the second phase of CRM training in the Queen Elizabeth Hospital and the Tuen Mun Hospital in 2013, and the programme was transformed from classroom teaching to small group specialty-based simulation training for four 'high-risk' departments, namely obstetrics and gynaecology, anaesthesia and operating theatre service, intensive care unit, and accident and emergency. In Queen Elizabeth Hospital, 380 frontline healthcare staff were recruited and the post-training survey revealed high overall rating of the programme, with a mean Likert scale score of 4.2 out of 5[57]. In Tuen Mun Hospital, 712 frontline healthcare staff were recruited and the post-training survey showed significant improvement of attitude towards patient safety with the application of CRM knowledge[58]. One-year post-training outcome evaluation also showed reduction of overrun elective surgery, late start-time in first elective cases, and same day elective surgery cancellation[58].

From 2012 to 2018, six different simulation training programmes, with incorporation of CRM principles, were developed in the department of obstetrics and gynaecology, Pamela Youde Nethersole Eastern Hospital (Figure 3). The training sessions were conducted at the simulation lab in the Hong Kong East Cluster Training Centre, with high fidelity robot anthropomorphic female simulators (Victoria and Noelle; Gaumard Scientific, Miami [FL], US). The effectiveness of these programmes was measured by two international standardised scales: the Debriefing Assessment for Simulation in Healthcare of the Center of Medical Simulation and the Simulation Design Scale (Figure 4).

In 2012, a half-day workshop for obstetrics and gynaecology doctors and midwives was organised. It consisted of two short lectures on obstetric emergencies, followed by two case scenarios taken randomly from the scenario bank. Participants were encouraged to apply CRM concepts to clinical practice and focus training on teamwork and communication apart from skills learning. Post-training survey showed a Simulation Design Scale score of 86 out of 100 and a Debriefing Assessment for

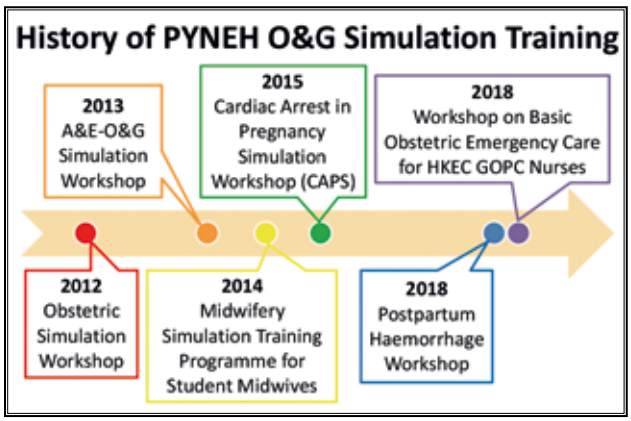

Figure 3. Six simulation training programmes in the department of obstetrics and gynaecology at Pamela Youde Nethersole Eastern Hospital

Measuring Tool for Outcome

Simulation design

Simulation Design Scale SDS (Chinese version)	No. of item
Objectives & information	5
Cues	4
Complexity	5
Feedback / Debriefing	4
Fidelity	2
5-point Likert scale (1-5), min 20, max 100	Total 20

Figure 4. The Simulation Design Scale for measuring effectiveness of simulation programmes

Simulation in Healthcare score of 38 out of 42[59].

In 2013, a cross-specialty half-day simulation workshop was organised in collaboration with the department of accident and emergency. The programme included short lectures followed by delivery skills demonstration and scenarios of obstetric emergencies with setup at the department of accident and emergency. A key objective of the workshop was to enhance communication and collaboration between the two departments in the management of obstetric emergencies. Post-training assessment among the 73 participants showed satisfactory evaluation of the course (70% or 95.9% gave a score of 4/4 or 4/5). The participants acknowledged the reinforcement of communication, clinical handover, and teamwork during the training. The exchange of knowledge and skills also enabled sharing and modification of guidelines to enhance patient safety[60].

In 2018, a simulation training workshop for the Hong Kong East Cluster General Outpatient Clinic staff was organised. Participants' relevant knowledge on obstetric emergencies improved significantly (passing rate: 43.3% pre-training vs 100% post-training)[61].

In 2014, a simulation training programme was designed for student midwives on delivery room teamwork and skills (including normal vaginal delivery, neonatal resuscitation, and repair of episiotomy), satisfactory scores in the Simulation Design Scale (89/100) and the Debriefing Assessment for Simulation in Healthcare (35.4/42) were recorded[62].

In 2015, an annual workshop for midwives on cardiac arrest in pregnancy was launched. The programme consisted of lecture and demonstration, and team learning on resuscitation of a pregnant patient with cardiac arrest in different scenarios. Pre- and post-training written tests showed significant improvement. Of the 96 participants, only 30.2% passed the pre-training test, reflecting significant knowledge and skills deficiency in the topic. All participants passed the post-training test, with an increment of 4.32 in the mean score (from 3.86 to 8.20, 95% confidence interval=3.99-4.64, $p<0.001$)[63].

Postpartum haemorrhage is a major cause of maternal death, and inaccurate estimation of blood loss is a contributing factor to suboptimal management. In 2017, a workshop was organised, with lectures and simulation stations on management of postpartum haemorrhage including estimation of blood loss. Pre-training test showed only 26.8% of participants had accurate assessment of blood loss (actual blood loss ±20%), with 33.4% underestimation and 39.8% overestimation; at 9 months post-training the accuracy rate was 45.1%[64].

Although training in a simulation lab with high-fidelity equipment may be costly and time-consuming, this can be addressed by adopting the principle of 'as reasonably realistic as objectively needed'[65] to implement simulation training with CRM elements.

Conclusion

Despite the lack of consistent evidence on clinical outcome improvement, simulation training augmented with CRM concepts has shown to improve and retain skills and knowledge as well as enhance teamwork and communication and eventually patient safety, with early identification and correction of clinical errors.

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