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RESEARCH ARTICLE
Intrapartum Care

Impact of simulation training on the management of shoulder dystocia and incidence of permanent brachial plexus birth injury: An observational study

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Abstract

Objective: To study the impact of shoulder dystocia (SD) simulation training on the management of SD and the incidence of permanent brachial plexus birth injury (BPBI).

Design: Retrospective observational study.

Setting: Helsinki University Women's Hospital, Finland.

Sample: Deliveries with SD.

Methods: Multi-professional, regular and systematic simulation training for obstetric emergencies began in 2015, and SD was one of the main themes. A study was conducted to assess changes in SD management and the incidence of permanent BPBI. The study period was from 2010 to 2019; years 2010–2014 were considered the pre-training period and years 2015–2019 were considered the post-training period.

Main outcome measures: The primary outcome measure was the incidence of permanent BPBI after the implementation of systematic simulation training. Changes in the management of SD were also analysed.

Results: During the study period, 113 085 vertex deliveries were recorded. The incidence of major SD risk factors (gestational diabetes, induction of labour, vacuum extraction) increased and was significantly higher for each of these factors during the post-training period ($p < 0.001$). The incidence of SD also increased significantly (0.01% vs 0.3%, $p < 0.001$) during the study period, but the number of children with permanent BPBI decreased by 55% after the implementation of systematic simulation training (0.05% vs 0.02%, $p < 0.001$). The most significant change in the management of SD was the increased incidence of successful delivery of the posterior arm.

Conclusions: Systematic simulation-based training of midwives and doctors can translate into improved individual and team performance and can significantly reduce the incidence of permanent BPBI.

KEYWORDS
birth, caesarean, emergency, multi-professional simulation-based training, permanent brachial plexus birth injury, shoulder dystocia management, trauma

1 | INTRODUCTION

Brachial plexus birth injury (BPBI) is usually a complication of a difficult delivery and is caused by traction to the cervical and thoracic nerve roots (C5–T1). The incidence varies from 0.4 to 3.8 per 1000 vaginal births.[1,2] Most mild injuries recover spontaneously,[2–5] and a permanent BPBI is defined as a clinically evident limited active or passive range of motion or decreased strength of the affected limb at the age of 1 year.[3–5]

The most significant risk factor for BPBI is shoulder dystocia (SD).[2,6] It is a highly unpredictable obstetric emergency that is defined by the American College of Obstetricians and Gynaecologists (ACOG) and the Royal College of Obstetricians and Gynaecologists (RCOG) as a delivery that 'requires additional obstetric maneuvers when gentle downward traction has failed to affect the delivery of shoulders'.[7–9] Maternal diabetes, obesity, fetal macrosomia and operative vaginal delivery are known to increase the risk for SD,[10–12] and thus for BPBI,[1] but a reliable prediction of SD is difficult. In Finland, the incidence of SD increased from 0.10% to 0.32% between 2004 and 2017,[10] and an increasing trend of associated risk factors has also been reported. During the last decade the mean maternal body mass index (BMI) increased from 24.4 to 25.5 kg/m^2, and the proportion of parturients who were obese (with a BMI of >30 kg/m^2) increased from 12.0% to 17.6%.[13] Between 2010 and 2019, the incidence of vacuum-assisted and induced labour increased from 11.1% to 12.5% and from 18.6% to 34.3%, respectively.[13] An increasing trend of SD,[14,15] and its associated risk factors,[16,17] is also being seen globally. However, the direct comparison of incidence rates for SD is difficult, as the uniform use of diagnostic criteria for SD is lacking.[18,19]

As SD and the risk for BPBI are difficult to control and predict, high-quality management and training of midwives and doctors is important. Various healthcare institutions have recommended simulation-based training,[20,21] but studies on the impact of training have shown contradictory results. In some studies, there is evidence for improved technical and non-technical skills (i.e. teamwork and communication skills),[22,23] as well as improvements in SD management and neonatal outcomes.[24,25] However, an associated increase in caesarean deliveries was seen in one study.[26] Despite the increasing number of studies,[27] reports on improvements in clinical outcomes are few and their results inconsistent.[27,28]

2 | METHODS

In 2014, Helsinki University Women's Hospital formulated a plan to perform regular simulation training for obstetric emergencies. Three specialists in obstetrics and gynaecology and six midwives attended Simulation Instructor Level 1 courses. Simulation Instructor Level 2 courses were attended by all trainers later in the study period.

In 2015, regular multi-professional simulation training for different obstetric emergencies (e.g. SD, postpartum haemorrhage, eclampsia, maternal collapse) was started on a weekly basis. Thereafter, weekly 3-h simulation-based training sessions have been conducted at the simulation centre of Helsinki University Women's Hospital. Between four and six midwives, one resident and one senior doctor participate in each training session. Midwives and doctors with limited work experience are given priority, and participation is mandatory for all hospital providers and is documented.

To support the participants' preparation, each receives electronic pre-training material, including a questionnaire, before the training commences. Each training session comprises a standardised three-phase structure that includes: (1) a briefing and introduction to the scenario(s); (2) simulation training based on each provider's own professional role; and (3) confidential debriefing. Two different scenarios are conducted with a resident, senior doctor and two or three midwives. Any midwives not participating in the scenario act as observers.

Shoulder dystocia (SD) is one of the main themes of the training. A pre-training lecture concerning the management protocol and manoeuvres for SD is included in the briefing for the training. A high-fidelity birthing simulator (The Noelle® 2200 Victoria; Gaumard Scientific, Miami, FL, USA; supplier Nordic Simulators, Lahti, Finland) is used for the simulation scenario, and a simple pelvic model (The Model-*med* Sophie and Sophie's Mum Birth Simulator®; supplier Steripolar, Espoo, Uusimaa, Finland) is used to train SD manoeuvres and technical skills. A standardised stepwise approach to the management of SD is taught, comprising the following:

1. Recognising and stating SD
2. Calling for help/mobilising the team
3. Informing the anaesthetist and paediatrician
4. Lowering the headboard
5. Interrupting oxytocin infusion
6. Applying the McRoberts manoeuvre
7. Performing an episiotomy, if possible
8. Applying suprapubic pressure
9. Trying internal rotational manoeuvres (Woods, Rubin)
10. Trying to deliver the posterior arm
11. If unsuccessful, repeating the manoeuvres or trying the all-fours position
12. If unsuccessful, performing a hysterotomy (symphysiotomy/Zavanelli)

A particular emphasis is placed on the technique for posterior arm delivery. A lateroposterior approach with the whole hand inserted into the vagina is discussed, demonstrated and individually taught in each training session. Participants are taught to grasp the fetal hand or lower arm, flex the elbow and deliver the arm by traction of the hand. Midwives are encouraged to perform the procedure in real SD situations by themselves, if indicated, before the arrival of the obstetrician.

Even though the posterior arm delivery technique is taught in detail, no one form of SD manoeuvre is taught as being superior to another. Participants are taught to always try the McRoberts manoeuvre and suprapubic pressure first and, if unsuccessful in delivery, are encouraged to try the technique that is presumably most successful. Providers are also taught to avoid potentially dangerous manoeuvres such as fundal pressure and the use of excessive force and pulling, as they both increase impaction of the anterior shoulder and the risk of brachial plexus damage. In addition to simulation-based training, 'walk-in' SD management skills stations are provided once a month for delivery room midwives and doctors.

The practice of non-technical skills, namely teamwork, reporting (Identification, Situation, Background, Assessment, Recommendation – ISBAR), communication (closed loop) and crisis resource management, is also taught and included in every simulation training session. All training is conducted by a team of certified simulation trainers from the hospital that includes a specialist in obstetrics and gynaecology and two or three midwives.

This retrospective observational study was conducted to analyse the impact of simulation training on the management of SD and the incidence of permanent BPBI. It covered the period from 2010 to 2019 and analysed 5-year periods before and after the regular training was implemented in 2015.

The characteristics of pregnancies and medical data for all livebirth deliveries (≥22 weeks of gestation or ≥500 g) during the study period were obtained from the Finnish Medical Birth Register of the Finnish Institute for Health and Welfare. The incidence of SD cases and data for risk factors (age, weight, abnormal glucose tolerance test, gestational age, induction of delivery, vacuum extraction, newborn weight) were analysed. The newborn outcome was analysed by collecting data on umbilical artery pH and 1-minute and 5-minute Apgar points.

Maternal intrapartum delivery documentation was reviewed for all cases of SD, which was defined as a delivery requiring additional obstetric manoeuvres to deliver shoulders after the head was delivered and gentle traction was unsuccessful. The follow-up management protocol was analysed in detail.

All cases with permanent BPBI were identified from the hospital database with International Classification of Diseases, Tenth Revision (ICD-10) codes P14.0–P14.3, and information concerning hospital in- and outpatient episodes was obtained from the hospital discharge register. A permanent BPBI was defined as clinically evident limited active or passive range of motion or decreased strength of the affected limb detectable at the age of 1 year. The diagnostic criteria for permanent BPBI and SD remained the same throughout the study period.

The Statistical Package for Social Science (SPSS Statistics V22.0; IBM, Armonk, NY, USA) was used for performing statistical analysis of the data and $p < 0.05$ was considered statistically significant. The chi-square test and the Mann–Whitney *U*-test were used to show between-group differences in categorical and continuous variables, respectively.

Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were used in reporting the results of this study and it was approved by the local ethics committee (registration number 79/E7/2001).

3 | RESULTS

During the study period, 140 016 deliveries were recorded at Helsinki University Women's Hospital, with a mean of 14 002 deliveries annually (12 747–14 996). The mean annual caesarean section rate was 19.4% (18.3%–21.0%), and the number of vaginal deliveries during the study period was 115 183. To analyse the impact of SD simulation training, all caesarean and breech deliveries were excluded from the analysis. The final data consisted of 113 785 deliveries in vertex position (81.3% of all deliveries).

3.1 | Primary and secondary outcomes

The Finnish Medical Birth Register identified 248 cases of SD in live birth deliveries during the study period. In two cases, the maternal delivery documentation showed no difficulty in delivering shoulders. These cases were excluded from the final analysis.

During the study period, the incidence of SD increased from 0.1% (1.2/1000 deliveries) to 0.3% (3.4/1000 deliveries) ($p < 0.001$). Despite increasing risk factors and cases of SD, the number of children with permanent BPBI decreased from 0.05% (0.5/1000 deliveries) to 0.02% (0.2/1000 deliveries) ($p < 0.001$). After the implementation of systematic simulation training, the risk for permanent BPBI among cases of SD was significantly lower (43.5% vs 6.0%, $p < 0.001$). Up to 67% of annual SD cases resulted in permanent BPBI during the pre-training period, but the percentage rapidly decreased to <12% after the implementation of simulation training (Figure 1).

The risk factors for SD and permanent BPBI, namely maternal age (31.2 ± 5.2 vs 31.7 ± 5.1 years, $p < 0.001$) and weight (65.11 ± 12.91 vs 65.88 ± 13.50 kg, $p < 0.001$) and the incidence of gestational diabetes (12.3% vs 18.5%, $p < 0.001$), were also higher during the post-training period. There was no difference in the incidence of primiparity (44.2% vs 44.2%, $p = 0.964$) and mean gestational age (39.9 ± 1.77 vs 39.9 ± 1.80 weeks of gestation, $p = 0.766$) at delivery. The incidence of induced (21.4% vs 25.2%, $p < 0.001$) and vacuum-assisted labour (12.5% vs 13.3%, $p > 0.001$), as well as caesarean deliveries (18.6 vs 20.0%, $p < 0.001$), was higher during the post-training period (Table 1).

The mean birthweight of all newborns (3493.9 ± 529.7 vs 3481.4 ± 527.4 g, $p = 0.043$) and the incidence of birthweight >4000 g (15.4% vs 14.6%, $p < 0.001$) and >4500 g (2.0% vs 1.7%, $p < 0.001$) were lower during the post-training period. However, there was no difference in the mean birthweight (4221.3 vs 4125.2 g, $p = 0.171$) and incidence of birthweight >4000 g (71.0% vs 61.4%, $p = 0.176$) and >4500 g (25.8% vs 23.9%, $p = 0.764$) among newborns with SD (Table 2).

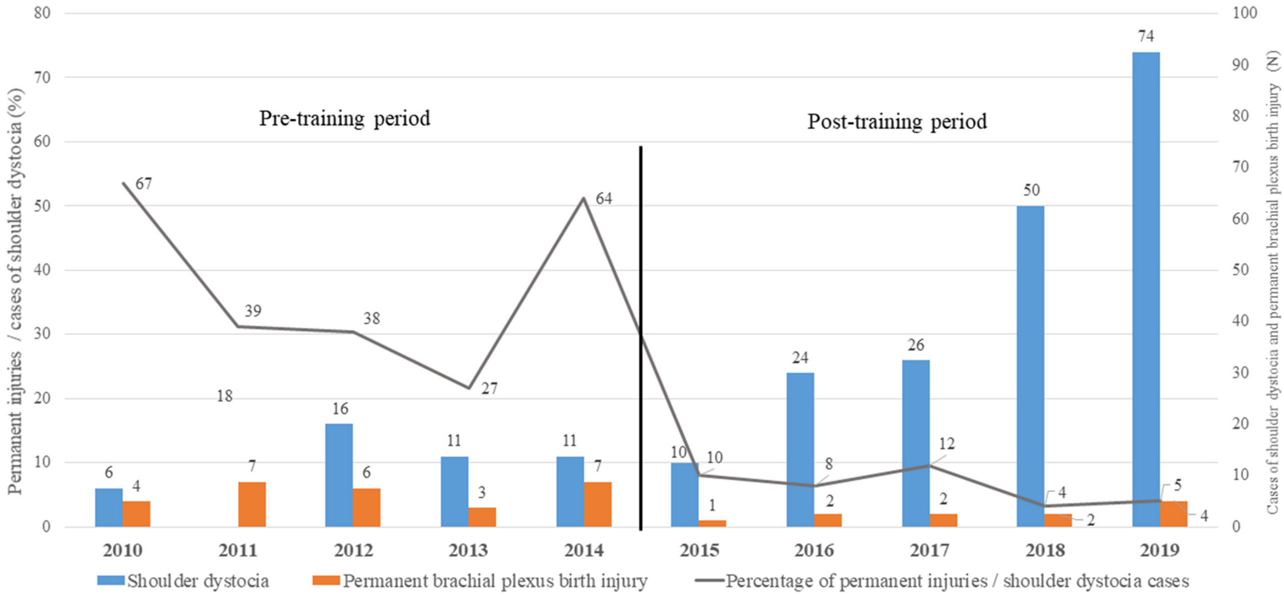

FIGURE 1 The impact of simulation training on the incidence of permanent brachial plexus birth injury.

TABLE 1 Maternal and delivery characteristics during the study period

	Pre-training period $n = 59709$	Post-training period $n = 54076$	p
Shoulder dystocia, n (%)/(n/1000)	62 (0.1)/(1.2)	184 (0.3)/(3.4)	<0.001
Permanent brachial plexus injury, n (%)/(n/1000)	27 (0.05)/(0.45)	11 (0.02)/(0.2)	0.02
Permanent brachial plexus injury/cases of shoulder dystocia, n (%)	27 (43.5)	11 (6.0)	<0.001
Maternal age (years), mean (SD)	31.2 (5.11)	31.7 (5.07)	<0.001
Maternal weight (kg), mean (SD)	65.11 (12.91)	65.88 (13.50)	<0.001
Gestational diabetes, n (%)	7353 (12.3)	10 006 (18.5)	<0.001
Primiparity, n (%)	26 382 (44.2)	23 886 (44.2)	0.964
Gestational age (weeks), mean (SD)	39.9 (1.77)	39.9 (1.80)	0.766
Induction of labour, n (%)	12 767 (21.4)	13 627 (25.2)	<0.001
Vacuum extraction, n (%)	7467 (12.5)	7216 (13.3)	<0.001
Caesarean delivery, n (%)	13 855 (18.6)	16 239 (20.0)	<0.001

The case documentation for SD showed that there was no difference in the use of the McRoberts manoeuvre (80.6% vs 87.0%, $p = 0.22$), suprapubic pressure (61.3% vs 52.2%, $p = 0.21$) and internal rotational manoeuvres (11.3% vs 17.9%, $p = 0.22$). The interruption of oxytocin infusion (0% vs 15.8%, $p < 0.001$) and successful posterior arm delivery (11.3% vs 23.4%, $p = 0.04$) were documented significantly more often in the post-training period. The documentation of fetal positioning (35.5% vs 36.4%, $p = 0.90$) and head-to-body delivery time (54.8% vs 40.8%, $p = 0.05$) did not improve during the post-training period. Fundal pressure was still used in a few cases (9.7% vs 5.4%, $p = 0.24$), and no reduction was seen during the post-training period. In most cases, the delivery of the shoulder was completed by a midwife (85.5% vs 87.0%, $p = 0.77$) (Table 3).

4 | DISCUSSION

4.1 | Main findings

Despite the increase in risk factors and SD cases, the incidence of permanent BPBI decreased significantly after the implementation of regular and multi-professional simulation-based training at our clinic. The most significant change in the management of SD was the increased rate of successful posterior arm delivery post-training.

4.2 | Strengths and limitations

The strengths of this study include its extensive and reliable register-based data on maternal and delivery characteristics

TABLE 2 Neonatal characteristics and well-being after delivery

All newborns during the study period	Pre-training period $n = 59709$	Post-training period $n = 54076$	p
Newborn weight, g (SD)	3493.9 (529.7)	3481.4 (527.4)	0.043
Newborn weight >4000 g, n (%)	9195 (15.4)	7866 (14.6)	<0.001
Newborn weight > 4500 g, n (%)	1207 (2.0)	938 (1.7)	<0.001
Newborn umbilical artery pH, mean (SD)	7.2 (0.81)	7.1 (0.93)	0.322
Apgar 1 minute, mean (SD)	8.7 (1.15)	8.64 (1.21)	<0.001
Apgar 5 minutes, mean (SD)	9.37 (1.14)	9.42 (1.06)	<0.001
Newborns with shoulder dystocia	**Pre-training period $n = 64$**	**Post-training period $n = 184$**	p
Newborn weight, g (SD)	4221.3 (481.5)	4125.2 (482.9)	0.171
Newborn weight > 4000 g, n (%)	44 (71.0)	113 (61.4)	0.176
Newborn weight > 4500 g, n (%)	16 (25.8)	44 (23.9)	0.764
Newborn umbilical atery pH, mean (SD)	7.21 (0.79)	7.10 (0.94)	0.344
Apgar 1 minute, mean (SD)	4.37 (2.60)	5.18 (2.62)	0.038
Apgar 5 minutes, mean (SD)	7.15 (2.18)	7.48 (1.88)	0.274

TABLE 3 Shoulder dystocia management and documentation

	Pre-training period $n = 62$	Post-training period $n = 184$	p
McRoberts manoeuvre, n (%)	50 (80.6)	160 (87.0)	0.22
Suprapubic pressure applied, n (%)	38 (61.3)	96 (52.2)	0.21
Interruption of oxytocin infusion, n (%)	– (0)	29 (15.8)	<0.001
Internal rotational manoeuvre, n (%)	7 (11.3)	33 (17.9)	0.22
Posterior arm delivery successful, n (%)[a]	7 (11.3)	43 (23.4)	0.04
Head-to-body time documented, n (%)	34 (54.8)	75 (40.8)	0.05
Fetal position documented, n (%)	22 (35.5)	67 (36.4)	0.90
Fundal pressure applied, n (%)	6 (9.7)	10 (5.4)	0.24
Delivery of shoulders by midwife, n (%)	53 (85.5)	160 (87.0)	0.77

[a]In cases in which posterior arm delivery was attempted.

and detailed permanent BPBI follow-up data by a specialised team. The use of a standardised SD management protocol and regular simulation training with the same team of certified trainers are also advantages our study.

Systematic simulation training at our clinic may have increased the recognition and diagnosis of SD and decreased the use of 'tight shoulders' diagnosis. However, these cases cannot be retrospectively identified and analysed, which can be considered a limitation of this study. As the number of SD cases during the pre-training period was small, the 'SD/tight shoulders' bias is likely to have caused high permanent BPBI incidences in 2010 and 2014. Even though a small bias in diagnostics is possible, the increasing trend of SD is consistent with the data on increasing risk factors and the increasing trend of SD seen in other studies.[7,11] A detailed comparison of incidence rates between studies is difficult, as the diagnostic criteria for SD are not always clearly stated and uniformly used.[15] This may also explain why the reported incidence in Finland is lower than that reported in other studies.[10]

4.3 | Interpretation

The results of our study provide strong evidence that the outcome for SD can be improved by systematic simulation-based training. A significant improvement in successful posterior arm delivery was detected, and the same result was also reported in the observational study by Croft et al.[15] In our clinic, the SD associated odds ratio of permanent BPBI before the systematic training was 12.13 (95% CI 5.51–26.72). Even though careful emphasis was placed on teaching the protocol and the technical management of SD, it should be highlighted that the importance of non-technical skills, namely teamwork, leadership, communication, situational awareness and workload management, was also discussed during each training session.[29]

Consistent with the results reported by Goffman et al.,[30] the documentation of SD management also improved. A significant improvement was detected in the documentation of interrupted oxytocin infusion. The implementation of a fill-in SD checklist and emphasis on the importance of documentation during simulation training sessions is likely to have increased the quality of documentation.[30]

It is important that the training of all providers is regular. According to previous studies, annual training is sufficient for those who are already proficient, but additional and individualised training should be arranged for those lacking sufficient competency.[15,31] While teaching appropriate techniques for the management of SD, it is equally important to put an end to the use of harmful practices.[32,33] The annual training of all providers is difficult in our sizeable clinic, with its continuous turnover of staff; however, the proportion of (at least once) trained providers has varied between 70% and 80%. We believe that this has been enough to improve common knowledge of the management of SD and teamwork at the clinic.

We detected an increasing trend towards gestational diabetes during the study period. This may, to some extent, explain the significantly increased incidence of labour induction and increased need for vacuum delivery. The increasing trend of these risk factors is consistent with the increasing trend of SD. The aforementioned factors are also likely to be associated with the increased incidence of caesarean deliveries. However, the increase in caesarean deliveries did not decrease the incidence of SD, and thus the risk of permanent BPBI. It is known from previous studies that as even the most powerful predictors are poor,[34] SD remains unpredictable. An unacceptable number of caesarean deliveries is needed to prevent one permanent BPBI.[35]

As previously mentioned, a permanent BPBI can occur after an uneventful vaginal or caesarean delivery.[36–39] During our study period, one case of permanent BPBI was seen after a caesarean delivery and one case was observed after a breech delivery. These cases were excluded from the final data analysis.

Shoulder dystocia (SD), the most common cause of permanent BPBI, is an obstetric emergency with possibly severe maternal and fetal complications. It is the second most common reason for litigation concerning childbirth.[40,41] As most providers face SD only a few times during their career, it is impossible to gain experience through clinical practice. The results of our study are promising and in keeping with those previously reported by Inglis et al.[42] In contrast to the conclusions of Wagner et al.,[26] we believe that simulation training can have a major impact on the outcome of SD. The role of simulation in patient safety has also been emphasised by the World Health Organization,[43] and the incorporation of simulation training into the certification processes for healthcare providers is recommended by ACOG.[44] Regular drills for obstetric emergencies, including SD, are also recommended by the US Joint Commission on Accreditation of Healthcare Organizations.[45,46] To improve and harmonise the role of simulation training across the country, in 2021 the Finnish Society of Perinatology published a recommendation for all providers working in obstetrics or neonatology to make arrangements for regular simulation training.[47]

The improvement of patient safety is the primary goal of simulation-based training, and investments in training are cost-effective. A cost–utility analysis performed by Yau et al. showed that the implementation of a nationwide simulation training programme for obstetric emergencies, or for SD alone, can result in significant cost savings when evaluating the impact on permanent BPBI.[48] The overall results concerning the impact of simulation-based training are reassuring and should further encourage the implementation of regular training at every clinic.

5 | CONCLUSION

Regular training of midwives and doctors and high-quality management of SD remain the most effective method for reducing maternal and fetal morbidity and preventing complications associated with substandard care.[41] This requires a dedicated team of educators and institutional investment so that staff can be regularly released from their clinical duties.

Even though we must be careful not to assume that the impact of simulation training on all obstetric emergencies is comparable, we feel encouraged to further develop the systematic simulation training programme in our clinic. However, future research on clinically measurable obstetric outcomes is still needed.

AUTHOR CONTRIBUTIONS

All authors have read and approved the article for publication. Study conception and design: MK, OÄ, AS and PG. Acquisition of data: MG and MK. Analysis and interpretation of data: MK and PG. Drafting of article: MK and PG. Critical revision of article: MK, OÄ and PG.

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CONFLICT OF INTERESTS

None declared. Completed disclosure of interests form available to view online as supporting information.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS APPROVAL

This study was approved by the local ethics committee (registration no. 79/E7/2001).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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