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Original Article

Vacuum-assisted delivery: An analysis of traction force and maternal and neonatal outcomes

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Abstract

Safety recommendations for vacuum-assisted delivery focus on limiting the number of pulls and the duration of the procedure. With the introduction of the Kiwi OmniCup vacuum extractor incorporating a Traction Force Indicator™, it is now possible to reliably monitor and control the amount of traction force exerted on the fetal scalp. The OmniCup was used in a prospective observational study of 119 vacuum-assisted deliveries in nulliparous women to establish practical guidelines for safe practice in typical clinical settings.

Key words: instrumental delivery, traction force, vacuum delivery, vacuum extraction.

Introduction

Within the strict methodology of randomised trials, reports of serious injuries associated with vacuum-assisted deliveries are rare.[1,2] Yet in the area of general obstetric practice adverse outcomes such as subgaleal haemorrhage, skull fracture and intracranial injury continue to be reported.[3,4] Safety measures recommended for vacuum-assisted deliveries include limiting the number of pulls,[5,6] restricting the duration of the procedure[7] and avoiding excessive traction.[8] Investigators have in the past attempted to define what forces constitute safe levels of traction during operative vaginal delivery.[9] The upper limits of safety are not known but a traction force of 23 kg has been suggested for forceps delivery.[10,11] There is therefore a need for established norms of maximum scalp traction associated with vacuum devices.[12] With the introduction of the Kiwi OmniCup incorporating a Traction Force Indicator™ (Clinical Innovations Inc., Murray, UT, USA), there is now available means of accurately measuring the traction force exerted on the fetal scalp.[13] The aim of this study was to determine what levels of traction force may be safely tolerated by the fetus and to establish practical guidelines for vacuum-assisted delivery in clinical practice.

Materials and methods

A prospective observational audit of 119 consecutive attempted vacuum deliveries of nulliparous women was undertaken during 2001 and 2002 at Caboolture Hospital, a level II obstetric facility and the Royal Brisbane and Women's Hospital, a regional tertiary referral centre in Queensland, Australia. Eligibility criteria were term gestation, a valid indication for expediting birth, and obstetric circumstances that were assessed to be appropriate for vacuum delivery. Women who fulfilled the selection criteria were informed of the study, and approval was obtained from the research and ethics committees of both hospitals. Thirty-eight (32%) of the vacuum deliveries were performed by obstetricians and 81 (68%) by obstetric registrars or residents in training.

The Kiwi OmniCup with traction force indicator was used for all vacuum deliveries[14] and all extractions were conducted in accordance with standard hospital protocols. Each vacuum delivery was divided into a *descent* phase and a *perineal* phase in accordance with the author's current practice.[15] The descent phase was defined as the part of the procedure from the time of cup application until the fetal head descended to the outlet of the pelvis (when the cup was completely visible within the introitus). The perineal phase was the part of the procedure from the time of complete cup visibility at the introitus to the time of delivery of the head. The peak traction force attained during each contraction was recorded by a separate observer, usually the author or a doctor or midwife who had been instructed in the method. For the purposes of analysis, vacuum deliveries were separated into two groups, namely, those extractions with a peak traction force less than 11.5 kg and those where the maximum recorded traction force was 11.6 kg or greater.

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Table 1 Obstetrical characteristics of vacuum assisted deliveries in nulliparous women related to the peak traction force

	All vacuum deliveries $n = 119$ (% or ± SD)	Traction force ≤ 11.5 kg $n = 95$ (% or ± SD)	Traction force ≥ 11.6 kg $n = 24$ (% or ± SD)
Primary indication			
NRFS	32 (26.9)	25 (26.3)	7 (29.2)
Second stage arrest	82 (68.9)	66 (69.5)	16 (66.7)
Maternal reason	5 (4.2)	4 (4.2)	1 (4.2)
Second stage (min)	115 (± 47)	114 (± 47)	119 (± 49)
Expulsion stage (min)	73 (± 30)	73 (± 31)	74 (± 24)
Station of the fetal head outlet	10 (8.4)	8 (8.4)	2 (8.3)
Low	74 (62.2)	62 (65.3)	12 (50.0)
Mid	35 (29.4)	25 (26.3)	10 (41.7)
Position of the head			
OA	50 (42.0)	41 (43.2)	9 (37.5)
OT	42 (35.3)	30 (31.5)	12 (50.0)
OP	27 (22.7)	24 (25.3)	3 (12.5)
Epidural	81 (60.1)	64 (67.4)	17 (70.8)
Birthweight (g)	3518 (± 481)	3513 (± 509)	3536 (± 355)

SD, standard deviation; NRFS, non-reassuring fetal status; OA, occipito-anterior; OT, occipito-transverse; OP, occipito-posterior.

Shortly after birth, the mother's genital tract was inspected by the operator for perineal lacerations and vulval or vaginal tears and the relevant obstetric data and procedural details were collected as soon as possible after the completion of each delivery. On the following day, the author or a study coordinator examined the scalp of each newborn infant to record any injury associated with the delivery.

Data were analysed using the GraphPad InStat (GraphPad Software, Inc., San Diego, CA, USA) statistical package. Results are expressed as means ± standard deviation (SD) or as rates (%). A P value of < 0.05 was considered significant. The relative risk (RR) and 95% confidence intervals (CI) were calculated where appropriate.

Results

Table 1 displays the clinical characteristics of all 119 vacuum-assisted deliveries and, in addition, the characteristics of the procedures where measured traction force was less than or exceeded 11.5 kg. Ninety-five (79.8%) extractions were achieved with a maximum traction force of 11.5 kg or less and 24 (20.2%) with a traction force greater than 11.5 kg. In only two cases did the traction exceed 13.5 kg. In 68 (57.1%) of the vacuum deliveries the peak traction force was recorded during the perineal phase, in 26 (21.9%) peak traction occurred during the descent phase and in 25 (21%) it was equal in the descent and perineal phases. Furthermore, for the 24 extractions where traction exceeded 11.5 kg, the maximum traction force was recorded on the perineum in 18 (75%), during descent in 4 (16.7%) and was equal in 2 (8.3%).

Procedural outcomes and maternal and neonatal effects are shown in Table 2. Although the mean duration for all vacuum deliveries was 10 min, it was significantly longer for the procedures that recorded the higher traction force. Overall, 102 (85.7%) of the extractions were completed in 15 min, 117 (98.3%) in 20 min and two (1.7%) deliveries in 21 and 24 min, respectively. The average number of pulls for all vacuum extractions was five. However, regardless of the traction force, the number of pulls applied during the descent phase was fewer than for the perineal phase of the vacuum delivery. Only 26.9% of the nulliparous mothers had their deliveries completed in three or fewer pulls, 63 (53%) within four pulls and 100 (84.1%) in six or fewer pulls, using the rule of three pulls for the descent phase and three for the perineal phase.[15] In no vacuum extraction did the number of pulls exceed four during the descent phase. Detachment of the cup occurred in eight (6.7%) extractions and vacuum delivery failed in 11 attempts (9.2%). Five of the cup detachments occurred in failed vacuum deliveries. Following unsuccessful vacuum extraction, the method chosen to complete the delivery was Caesarean section in five patients, outlet forceps in five and spontaneous vaginal delivery in one patient.

Injury to the maternal genital tract is also displayed in Table 2. Third-degree perineal lacerations were recorded in 14 (11.8%) mothers but were more frequent in the deliveries that were associated with a higher traction force. Eleven of the 14 women who sustained sphincter lacerations also had an episiotomy to facilitate delivery.

Neonatal scalp abrasion and cephalhaematoma were more common in infants delivered with traction that exceeded 11.5 kg. One infant who was included in the 'cephalhaematoma' group for the purposes of analysis in fact sustained a small subgaleal haemorrhage. During this infant's vacuum delivery, traction force reached 13 kg and the procedure was completed in five pulls over 17 min duration. Station of the fetal head was low (+2 cm) and the position occipito-transverse. Application of the vacuum cup on the fetal scalp was deflexing and paramedian.

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Table 2 Clinical outcomes of vacuum assisted deliveries in nulliparous women related to the peak traction force

	All deliveries $n = 119$ (% or ± SD)	Traction ≤ 11.5 kg $n = 95$ (% or ± SD)	Traction ≥ 11.6 kg $n = 24$ (% or ± SD)	RR (95% CI)	*P* value
Procedural outcome					
Duration (min)	10 (± 5)	9 (± 4)	14 (± 5)		< 0.001
Total number of pulls	5 (± 2)	4 (± 2)	6 (± 2)		< 0.001
Pulls for descent	2 (± 1)	2 (± 1)	2 (± 1)		ns
Pulls across perineum	3 (± 1)	3 (± 1)	4 (± 1)		< 0.001
Cup detachment	8 (6.7)	6 (6.3)	2 (8.3)		ns
Failed vacuum delivery	11 (9.2)	8 (8.4)	3 (12.5)		ns
Maternal outcome					
Intact perineum	18 (15.1)	15 (15.8)	3 (12.5)		ns
Episiotomy	66 (55.5)	50 (52.6)	16 (66.7)		ns
1° and 2° laceration	32 (26.9)	29 (30.5)	3 (12.5)	2.44 (0.81–7.35)	ns
3° perineal laceration	14 (11.8)	9 (9.5)	5 (20.8)	0.45 (0.17–1.23)	ns
Neonatal outcome					
Scalp abrasion	7 (5.9)	4 (4.2)	3 (12.5)	0.34 (0.08–1.41)	ns
Cephalhematoma	10 (8.4)	6 (6.3)	4 (16.7)	0.38 (0.12–1.24)	ns

SD, standard deviation; RR, relative risk; NRFS, non-reassuring fetal status; ns, not significant.

Discussion

The results of this study suggest that with correct technique, a traction force of 11.5 kg is relatively safe for the infant and mother and should be sufficient to achieve vaginal delivery in at least 80% of vacuum extractions. In addition, the data indicate that virtually all deliveries may be completed with a traction force that does not exceed 13.5 kg, but that at these higher traction levels, there is an increased risk of maternal sphincter damage and fetal scalp injury. It should be mentioned, however, that although the infant who sustained a subaponeurotic haemorrhage was in the higher traction force group, the major predisposing factor for the injury was incorrect technique by the operator.

It is perhaps simplistic to talk about maximum traction force levels in isolation as total force depends also on the number of pulls and the duration of traction.[8] Higher levels of traction force and a greater number of pulls were required in most cases during the outlet phase of the vacuum delivery than during the descent phase. The explanation may be that, at this stage, resistance is greatest as the widest part of the fetal head is crossing the narrowest section of the maternal birth canal. For this reason, it would seem logical to allow additional time and pulls for the perineum to stretch over the head as is practised with normal delivery especially if the birth is managed without episiotomy.

In summary, the results of the study indicate that at least 80% of nulliparae and their infants may be delivered by vacuum extraction with relative safety if the traction force does not exceed 11.5 kg and, in addition, if the duration of the procedure is restricted to 15 min and the number of pulls is limited to three for the descent phase and three for the perineal phase. It may still be possible for experienced operators to safely exceed these general recommendations, but the findings of the study suggest that vacuum extractions extending beyond 20 min duration and requiring greater than 13.5 kg traction force should be rare.

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