USE OF THE VACUUM EXTRACTOR

BY

MOSHE LANCET, B.A.(Med.), M.D.

Department of Obstetrics and Gynaecology, Kaplan Hospital, Rehovoth, Israel

Malmström's vacuum extractor (V.E.) is attracting considerable attention. Nevertheless there is a certain reluctance to try out this relatively new instrument. Most obstetricians think that forceps are good enough and see no reason to abandon them, whether partially or totally. But the wide range of different forms of forceps seems to suggest some inherent deficiency which innovators try to circumvent. The ideal instrument for expediting delivery should have the following main characteristics; cause no injury to the mother or the infant; be applied easily in all positions; and not interfere with the physiological movements of the head in the birth canal. This would also mean that the problem of correct cephalic or pelvic application should not exist. Some of these requirements cannot be fulfilled by forceps, and the completely different mechanics of the V.E. might be at least a partial answer.

There have been numerous descriptions of the V.E. and the technique of its use (Malmström, 1953, 1954, 1957; Evelbauer, 1958; Rossboth, 1959; Chalmers and Fothergill, 1960; Tricomi *et al.*, 1961).

Method and Material

Detailed notes have been taken in each case, including indications, exact technique, time of operation, results, etc., and these form the main theme of this article. I feel that most publications on this subject have not considered these practical details, and therefore have shown only part of the picture. Finally, the maternal morbidity in the V.E. cases is compared with that in a comparable group of forceps deliveries.

The present series consists of 81 consecutive non-selected cases delivered by the V.E. The age and parity of the patients are given in Tables I and II. The majority (64.2%) were primiparae, most of them (67.8%) were in the 21-30 age-group.

TABLE I.—Parity

Parity	1	2	3	4	5	6+
No. of cases	52	12	3	5	2	7

TABLE II.—Age of Patients

Age	<21	21-25	26-30	31-35	36-40	Over 40
No. of cases	9	35	20	13	3	1

Indications

The range of indications for the V.E. is much wider than that of the forceps, as the extractor can be applied when the cervix is not fully dilated and with the head in the high plane of the pelvis.

Table III gives all the indications for the application of the V.E. It will be seen that in most cases the first or second stage of labour was prolonged. The total number of indications exceeds that of the cases, as sometimes two or more indications existed in one patient. I wish to draw attention to the 10 cases of imminent asphyxia of the foetus, a subject which is dealt with in the discussion.

In five cases there was a partial deflection of the head. By applying the cup of the extractor to the most posterior part of the head (as near to the occiput as possible), flexion is effected by the traction.

There were two cases of prolapse of the umbilical cord. The first was in a quadripara at full dilatation with the head in the mid-pelvis and no pulsations in the cord. By continuous traction a large baby was extracted; it cried immediately. In the second case, again a quadripara, the head was high at the pelvic brim, with many loops of the cord before it. The cup could not be applied as the cord was repeatedly sucked into it, and 15 minutes later a live baby was extracted by forceps, the head having become engaged in the meantime.

In one case the whole arm, almost to the shoulder, had prolapsed, and the delivery became arrested with both the head and arm crowding at the pelvic outlet. Even if forceps could have been applied the space in

TABLE III.—Indications

Indication	No. of Cases
Prolonged second stage	34
first	24
Persistent occipito-posterior	22
Deep transverse arrest	20
Primary and secondary inertia, including incoordinate pains	18
Cervical rigidity	14
Imminent asphyxia of infant	10
Deflexion of head	5
Hypertonic uterine inertia	3
Post-caesarean state (not the only indication)	4
Prolapse of the umbilical cord	2
Partial premature separation of placenta	1
Prolapse of arm	1
Frank breech with inertia	1
State after cerebral haemorrhage (H.C.V.D.)	1
Mitral stenosis	1
Congenital ventricular septal defect	1
Diabetes	1

the pelvis would have become even less, and it is doubtful whether delivery could have been accomplished without serious injury to the mother and the infant. By using the V.E. the baby was easily extracted, without any damage to either participant.

The V.E. can be applied to the breech, especially in frank breech, when the labour is not advancing normally. We used it once with complete success. Opinions differ on this subject (Evelbauer, 1958; Berggren, 1959; Dörffler, 1959; Hochuli and Stöckli, 1960).

State of Labour

As stated above, one of the important advantages of the V.E. over forceps is the possibility of using the former when the cervix is not fully dilated, or when the head is in the pelvic inlet.

Cervical Dilatation.—Table IV shows the state of the cervix at the time the cup was applied. By using traction synchronously with the uterine contractions, complete dilatation is reached rapidly, even if the cervix was stationary at incomplete opening for hours.

Level of Foetal Head.—Table V shows the situation of the head in the pelvis when the extractor was applied. In 11 cases the head was in the high plane. It is not advisable to use the V.E. on the floating head.

TABLE IV.—Cervical Dilatation when Instrument was Applied

Dilatation	Full	9 cm.	8 cm.	6 cm.	5 cm.
No. of cases	48	18	8	6	1

TABLE V.—Level of Head when Instrument was Applied

Level	Outlet	Low Plane	Mid-plane	High Plane
No. of cases	5	19	46	11

as in such cases there is a possibility of cephalo-pelvic disproportion.

Position of Foetal Head.—The position of the head in the pelvis poses an important problem when forceps are applied. In the transverse position an instrument without pelvic curvature (like the Kielland) has to be used, or regular forceps have to be applied without due consideration to correct cephalic application. In any case, either the soft maternal tissues or the foetus, or both, suffer. The operation itself does not allow for rotation owing to the physiological forces of the contractions and passages, but the head has to be rotated artificially, sometimes at the expense of severe lacerations. The cup of the V.E. is easily applied to the head in any position, and in most cases spontaneous rotation occurs by traction alone. A rotating movement can be added by pressing on the button of the cup, but this is scarcely ever necessary. Out of 22 cases of persistent occipito-posterior position and 20 of transverse arrest (a total of 42), rotation was "helped" in only seven, when we had just begun to use the V.E. and were still sceptical about the ease of spontaneous rotation. In two cases the head emerged with the face towards the pubis, but in all the remaining 33 the head rotated by itself to the occipito-anterior position. In one case it described an arc of 270 degrees.

Uterine Contractions.—The use of the V.E. brings about a regularization of abnormal contractions, be they weak, incoordinate, or irregular. Synchronous traction increases the force and length of labour pains. The possible explanation of this phenomenon lies in the close application of the foetal head to the cervical rim through the traction, and by reflex action the uterine muscles become more active. In 33 cases the contractions were of medium strength, while in 10 they were weak, and by traction they became strong and regular in all these patients. In cases of various disturbances of the uterine contractions, medication was tried so as to overcome the difficulty encountered before deciding to use the V.E. In our department pethidine infusion in glucose, sometimes combined with "pitocin" infusion (in two bottles put up simultaneously), or pitocin infusion alone is used in such cases. Before the application of the V.E., 23 patients received a combined infusion, 11 pethidine, and 4 pitocin alone.

Expulsion Time.—Forty-five women were in the second stage of labour when the instrument was applied. Table VI shows the time of expulsion in these cases. We are not orthodox about the maximal time of bearing down, and we help the parturient when, after a reasonable lapse of time, there is no progress in labour.

TABLE VI.—Time of Expulsion Before Operation

Time (minutes)	0	30-60	60-90	90-120	Over 120
No. of cases	36	8	22	8	7

Mode of Application

Size of Cup.—The V.E. has four cups of different diameters, No. 1 being the smallest and No. 4 the largest. They are applied according to the cervical opening, and at full dilatation No. 4 should be used. When the vagina is very narrow and/or the head is higher than the pelvic outlet, the largest cup cannot be applied easily. In such cases a No. 3 cup is used, even with full dilatation. In general the smaller the cup the more easily it becomes detached when strong traction is applied. Therefore we usually changed to No. 4 after

reaching full dilatation. In 43 cases a No. 4 cup was used and in 28 a No. 3. With eight women two different cups were used, while in one patient we applied Nos. 2, 3, and 4 successively.

Anaesthesia.—The instrument is applied without general anaesthesia, as it causes no undue discomfort to the patient. Either local infiltration with 1% procaine hydrochloride or bilateral pudendal block (transperineal) was used. In some cases the two methods were combined, while in others no anaesthesia was needed. The choice of method depended on several factors: parity, the size of the vagina, the level of the head, and the sensitivity of the patient. Local infiltration was used in 45 cases, pudendal block in 19, and a combination of the two in 9. Eight women were delivered without any anaesthesia.

Mode of Traction.—The V.E. is used with a fully conscious and co-operative patient, and there is no hurry to finish the operation. The best results were obtained when traction was applied synchronously with the uterine contractions. This is imperative when dilatation is incomplete, while in the second stage the parturient is urged to bear down during the contractions and traction is made at the same time. Continuous traction is advisable when signs of foetal distress are present. Synchronous traction was used in 69 cases, continuous in 9, and both in 2.

The total time of traction depends of course on the state of labour at the beginning of the operation. If the cervix is only partially dilated, the head is high, or internal rotation is not completed, we must pull for a longer period (Table VII). Seventy-two cases were delivered within 20 minutes, while in one case the operation lasted for 70 minutes (beginning with a dilatation of 5 cm., at which it had been stationary for nine hours).

TABLE VII.—Time of Traction

Time (minutes)	1-3	4-10	11-20	21-30	31-45	70
No. of cases	28	31	13	5	2	1

Although some authors (Fauvet, 1958; Büttner, 1959; Chalmers and Fothergill, 1960) fix an arbitrary time limit of 45 to 60 minutes, we have not seen any deleterious effect on either the woman or the baby after such a prolonged application. The only drawback of a long delivery with the V.E. is that it taxes the patience of the obstetrician.

Detachment of the cup is possible, especially if traction is in an incorrect direction. Reapplication is done with no adverse effects. There was one case of failure in the beginning of the trial period, when, owing to incorrect direction of traction, the cup became detached three times, and delivery was completed by L.P. forceps.

The Foetus

The problem of possible foetal suffering due to the application of the V.E. is, of course, very important. Phonocardiographic records were made by Snoeck (1960) at the time of operation, and no changes in the foetal heart rate were found. In the present series auscultation of the heart beats was done in all patients between synchronous tractions throughout the operation. Excepting where imminent asphyxia was present prior to the application of the V.E., in no case could any change in the cardiac rhythm of the foetus be detected.

The state of the infants immediately after delivery is shown in Table VIII, in which only 78 cases appear,

as two were delivered by forceps, and one was dead *in utero* before delivery. Two babies were born with asphyxia: in one case, which was probably due to a large dose of pethidine that the mother had received, the infant was resuscitated by *N*-allylmorphine. The second infant was in a very bad state, started breathing after 15 minutes, and died subsequently (see below).

Immediately after delivery a large mushroom-like excrescence occurs on the scalp, but it disappears rapidly. The times of disappearance are given in Table IX.

During the first two post-natal days slight excoriations are seen in about 50% of the infants. Each baby was carefully examined on the day it left hospital (half of them by the fifth day of life), and Table X shows the results of this examination. No treatment was ever needed, but in three cases there was a small cephalhaematoma. This may be expected in spontaneous deliveries as well.

TABLE VIII.—*Lapse of Time Before First Cry of Newborn*

Time (minutes) ..	0	1	2	3	4	5+
No. of cases ..	66	5	3	1	1	2

TABLE IX.—*Time of Disappearance of Scalp Excrescence*

Time (minutes) ..	<16	16-30	Over 30
No. of cases ..	29	44	6

TABLE X.—*Signs of Scalp on Day of Leaving*

Sign	No. of Cases
Nil	51
Redness (skin intact) ..	13
Slight scratch or crust ..	12
Cephalhaematoma ..	3

A follow-up of the babies at the age of 1 month was carried out by the paediatricians. Not all mothers returned for such a visit, and up to the time of writing 63 infants had been examined regarding the scalp, general development, and reflexes. All those examined were found to be completely normal, including babies delivered by the V.E. before full dilatation of the cervix.

These findings concur with those of others (Malmström, 1957; Evelbauer, 1958; Berggren, 1959), who have followed 1,400 children up to the age of 3-5 years and found all of them in excellent condition.

Perinatal Mortality.—In one case the instrument was applied to the breech of a dead foetus (severe pre-eclampsia). There were two neonatal deaths: one on the fifth day of life during an exchange transfusion, and another on the third day with massive subcapsular haemorrhage of the liver, haemoperitoneum, and confluent bronchopneumonia. According to the pathologist neither could be attributed to the vacuum extractor.

Maternal Morbidity

Most authors (Malmström, 1953, 1954, 1957; Evelbauer, 1958; Büttner, 1959; Hochuli and Stöckli, 1960; *Lancet*, 1961; Lange, 1961) claim that maternal complications and morbidity are less after a delivery by V.E. than by forceps. We compared our cases with 79 consecutive unselected forceps deliveries, and Tables XI and XII show the number of febrile days and maximum fever in both groups. The numbers are not impressive, but they definitely favour the V.E. group. We must stress that fever cannot always be attributed to the operation, as there were cases of mastitis, manual removal of the placenta, etc.

F

Episiotomy is done in most V.E. cases. Nevertheless, we had 62 episiotomies in this group compared with 74 in the forceps cases. Lacerations of the vagina and/or perineum were seen in 9 and 16 patients respectively. In addition there were three lacerations of the sphincter ani in the forceps group, and one in a V.E. patient who was extremely obese with fat folds of the thighs that prevented effective protection of the perineum. In no V.E. case have we seen an extension of the episiotomy to the vaginal fornix, which is quite common in forceps deliveries. In the forceps group there were other com-

TABLE XI.—*Number of Febrile Days (Comparison Between V.E. and Forceps)*

Days of Fever:	0	1	2	3	4	5	6	8	9
No. of mothers { V.E. ..	43	17	9	4	3	2	1	0	0
{ Forceps ..	34	19	11	3	4	2	1	3	2

TABLE XII.—*Maximum Fever of Mother (Comparison Between V.E. and Forceps)*

Maximum Fever (°C.)	No. of Mothers V.E.	No. of Mothers Forceps
37.5-38	24	31
38-38.5	11	14
38.5-39	1 (mastitis)	0

plications: two cases of shock, four infections of the episiotomy, one secondary suture, and in two patients severe haemorrhage from vulvar varices. There was one depression fracture of a cranial bone of the infant, which of course cannot occur with the V.E.

Some authors (Dörffler, 1959; Hochuli and Stöckli, 1960) claim that they have never seen a cervical laceration when the V.E. was applied at incomplete dilatation. At the beginning of our work with the instrument we found small non-bleeding lacerations in 9 cases (out of a total of 33 at incomplete dilatation), some of which had to be sutured. We have learned in the meantime that only patience and not too strong synchronous traction will prevent cervical lacerations in these cases.

It is interesting to note that although forceps are applied only with apparent complete dilatation there were 10 lacerations in the control group, with one annular detachment.

Discussion

When a new instrument is introduced it is necessary to find out what changes it involves in our general obstetrical comportment.

Table XIII enumerates the frequency of obstetrical operations in two equal periods of time (10½ months): the first before and the second after the introduction of the V.E. The percentage of caesarean sections is equal, although we had definite cases in which it was felt that without the V.E. we should have had to resort to section. These were prolonged first-stage labours, with rigid cervixes or weak and incoordinate contractions (in spite of pethidine and pitocin infusions). We tried the V.E. in these patients, although a caesarean was indicated, and to our pleasant surprise all of them

TABLE XIII.—*Obstetrical Operations (Comparison Between Two Equal Periods of Time)*

Period	No. of Deliveries	Caesarean Sections	Forceps	V.E.
Before use of V.E.	2,225	40 (1.79%)	62 (2.8%)	0
After introducing V.E. ..	2,003	35 (1.74%)	6 (0.3%)	81 (4%)

were easily delivered in a short period of time. This is especially important in primiparae, in whom an unscarred uterus is of great significance.

The percentage of forceps deliveries has fallen almost to nil, and during the last eight months not one forceps was applied in our department.

From our study it is evident that the V.E. can replace the forceps in almost all the latter's indications, except in face presentation and on the aftercoming head, and perhaps in very urgent cases of imminent asphyxia. In most cases of asphyxia there is enough time for the V.E., taking into consideration also that the additional hazards of general anaesthesia are avoided. We therefore agree with Finderle (1955), Bruniquel and Israël (1958), Voegeli (1958), and Snoeck (1960), who think that the V.E. will lessen the use of forceps almost to zero. There are others (Evelbauer, 1958; Tricomi *et al.*, 1961) who are opposed to this idea, but they have artificially restricted the use of the V.E. to certain cases exclusively. In general it is obvious that the V.E. has a far wider range of indications than the forceps.

One of the important advantages of the V.E. is that there is no need for general anaesthesia, and doubtless this lowers the complications in both partners involved in the process of delivery.

The problem of intracranial damage has engaged many obstetricians. Rosa (1955) and Snoeck (1960) have made accurate mathematical calculations and have concluded that the intracranial pressure during traction with the V.E. is 20 times less than when the same force is applied to the forceps. The force of traction applied to the V.E. during delivery is less than that needed with the forceps (Brey and Fanghänel, 1960). It is a fact that in more than 2,000 cases (including our own) there were only two in which neonatal death was due to intracranial haemorrhage. In one, the authors (Hochuli and Stöckli, 1960) think that it had occurred during labour, as severe signs of asphyxia were present at the time the V.E. was applied. The other case was reported by Huntingford (1961), who in a small series found quite a large proportion with light or severe damage in the scalp or brain. His results are not comparable with any of the previously published articles, nor have we seen any injury in 33 infants delivered *before* full dilatation. Fulst (1960) examined the eye-grounds of hundreds of infants born with the V.E. and found no pathological changes. In the two cases of neonatal death that occurred in the present series care was taken by the pathologists to examine the head, and they found the changes compatible with spontaneous delivery.

As to the mother, we have shown that morbidity and complications are less with the V.E. than with forceps. It is imperative, of course, that the perineum be efficiently protected, otherwise deep lacerations are possible as with any other form of vaginal delivery.

The V.E. can be easily used with the head in an abnormal position, slight to moderate deflexion, or high in the pelvis. In all these situations the forceps must be used with the utmost care or not at all. It is the ideal instrument for the second twin presenting with a high head.

The use of the instrument synchronously with an awake mother enables her to help by her bearing-down efforts, and thus decreases to a large degree the strength of traction. If too much force is applied or its direction is not physiological, the cup will become detached, with no serious damage to either mother or infant.

The simplicity of the application of the V.E. allows its use by relatively young and inexperienced physicians if the rules of its correct operation are kept.

Conclusions

The vacuum extractor is an efficient and versatile obstetrical instrument which can replace forceps with advantage in most cases, and prevent a caesarean section in some of them.

The following rules must be kept to obtain good results: (1) clear indication for the operation; (2) careful vaginal examination before the application of the cup; (3) the slow formation of vacuum down to -0.8 – -0.9 atmos. during four to five minutes; (4) renewed examination before traction is started to ascertain that no maternal soft tissue has been sucked into the cup (otherwise the vacuum has to be released and the cup reapplied); (5) traction in the correct direction according to the level of the head in the pelvis; and (6) post-delivery exploration of the cervix if the cup has been applied before full dilatation.

Summary

The results of experience with the vacuum extractor of Malmström are given.

Experience with the first unselected 81 cases proved the extractor to be versatile, efficient, and easy to use.

The indications for its use cover a wide range and include mainly prolonged labour due to uterine inertia, cervical rigidity, or incoordinate contractions.

The V.E. has the following advantages over the forceps: it can be used when the cervix is not fully dilated and the head is in the high plane; the application to the head is easily carried out when the latter is in an abnormal position, and spontaneous rotation usually occurs through traction alone. No general anaesthesia is needed, and the mother can help the manoeuvre by her expulsive forces. There is practically no damage to the maternal soft tissues.

No damage occurred to the foetal head. The intracranial pressure is 20 times less than when forceps are applied.

The V.E. can replace the forceps in almost all cases when the latter is indicated, beside covering many other indications. In certain cases it can be used instead of a caesarean section.

ADDENDUM.—Since the completion of this article 74 1-month-old V.E. infants have been seen by the paediatricians, and all were found to be absolutely normal. Fifty-six babies have been followed up between 11 and 20 months of age, and, except for one case of congenital torticollis and one of craniotabes (rickets?), all were well developed and healthy.

I thank the Institute of Pathology and Paediatric Department B, Kaplan Hospital, for examinations performed in connexion with this paper.

REFERENCES

- Berggren, O. G. A. (1959). *Acta obstet. gynec. scand.*, **38**, 315.
- Brey, J., and Fanghänel, M. (1960). *Geburtsh. u. Frauenheilk.*, **20**, 1357.
- Bruniquel, G., and Israël, A. (1958). *Gynec. et Obstét.*, **57**, 222.
- Büttner, W. (1959). *Med. Klin.*, **54**, 1232.
- Chalmers, J. A., and Fothergill, R. J. (1960). *Brit. med. J.*, **1**, 1684.
- Dörfler, P. (1959). *Med. Klin.*, **54**, 1234.
- Evelbauer, K. (1958). *Fortschr. Med.*, **76**, 553.

- Fauvet, E. (1958). *Geburtsh. u. Frauenheilk.*, **18**, 82.
 Funderle, V. (1955). *Amer. J. Obstet. Gynec.*, **69**, 1148.
 Fulst, W. (1960). *Zbl. Gynäk.*, **82**, 321.
 Hochuli, E., and Stöckli, A. (1960). *Geburtsh. u. Frauenheilk.*, **20**, 346.
 Huntingford, P. J. (1961). *Lancet*, **2**, 1054.
 Lange, P. (1961). *Dan. med. Bull.*, **8**, 11.
 Malmström, T. (1953). *Nord. med.*, **50**, 1311.
 — (1954). *Acta obstet. gynec. scand.*, **33**, Suppl. 4.
 — (1957). *Ibid.*, **36**, Suppl. 3.
 Rosa, P. (1955). *Bull. Soc. roy. belge Gynec. Obstet.*, **25**, 142.
 Rossboth, W. (1959). *Wien. med. Wschr.*, **109**, 252.
 Snoeck, J. (1960). *Proc. roy. Soc. Med.*, **53**, 749.
 Tricomi, V., Amorosi, L., and Gottschalk, W. (1961). *Amer. J. Obstet. Gynec.*, **81**, 681.
 Voegeli, H. (1958). *Gynec. et Obstet.*, **57**, 95.

NOMOGRAMS FOR RATES PER 1,000

BY

S. ROSENBAUM, M.A., Ph.D.
 Army Medical Department

A series of three nomograms is presented as an aid in assessing the significance of rates per 1,000, which depends, of course, upon the numbers at risk. These nomograms are extensions of a previous set (Rosenbaum, 1959), which were expressed as percentages, and where the size of sample did not exceed 4,000. The derivation of the nomograms is explained in that paper, and is not repeated here. The size of sample is now extended to 1,000,000, and the three problems originally dealt with on a single nomogram are now separated for greater clarity. The range of values formerly covered is included in the present set.

I. Confidence Limits to a Rate

In the first nomogram the right-hand scale *m* shows the size of sample; the left-hand scale *p* shows the rate per 1,000 being considered. On joining them by a straight line, the point at which the central scale is cut indicates the 95% and 99% confidence limits to the rate *p*.

Example.—In the week ending September 16, 1961, 15,658 births were recorded in England and Wales, of which 291 were stillbirths (*Brit. med. J.*, 1961). This represents a rate of 18.6 per 1,000. If a ruler is placed across the nomogram from this point on the left-hand scale to 15,658 on the right-hand scale, it cuts the centre scale at the value 2.1 on the 95% side, and 2.8 on the 99% side. Thus the 95% confidence limits to the rate are ± 2.1 , and the 99% confidence limits are ± 2.8 . Note that these are also the confidence limits to the rate of live births, 981.4 per 1,000.

It should be pointed out that the confidence limits also provide a test for the significance of a difference from a standard rate which is known without any presumption of error, the criterion being whether the confidence limits embrace the standard rate or not. For example, if there were a standard stillbirth rate of 20 per 1,000 the 95% confidence limits obtained above—namely, 16.5 and 20.7—include this value, and so the difference is not significant.

The nomogram cannot be used for a very small value of *p* and at the same time of *m*. It is probably safe to use when *p* is based on 10 cases or more.

II. Difference Between Two Rates

In the second nomogram we are interested in comparing two rates *p* and *q*, one based on a sample of size *m*, and the other on a sample of size *n*. The left-hand scale shows the size of the two samples combined, $N=m+n$. The right-hand scale shows the two rates added together, $P=p+q$.

If these points are joined by a straight line the central scale is cut at a point which indicates whether the difference $p-q$ is significant or not. That is to say, if $p-q$ is greater than the value indicated on the 5% side of the central scale it is significant at the 5% level, and similarly on the 1% side.

Example.—The first report of the Medical Research Council tuberculosis vaccines trial (M.R.C., 1956) covered the incidence of tuberculosis during the first

Nomogram I. Confidence limits to a rate.

Nomogram II. Difference between two rates.

Nomogram III. Comparisons in the same population.