Estimating success of vaginal birth after caesarean section in a regional Australian population: validation of a prediction model.

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Abstract:

Background: Following a primary CS, women must decide between attempted vaginal birth after caesarean (VBAC) and elective repeat caesarean section (ERCS) in subsequent pregnancies. Both options carry potential morbidity and mortality for mother and child, with the most feared being uterine rupture and its consequences. In attempts to reduce morbidity, several predictive nomograms have been developed to assist in delivery mode decisions. Aim: To assess the validity of the predictive nomogram developed by Grobman et al in our regional Australian population. Materials and Methods: In our retrospective analysis, patients at term, with one previous CS who had a trial of labour were assigned a 'Grobman score' based on antenatal details. Outcomes were noted and patient groups analysed according to percentage deciles of estimated VBAC success, compared with actual VBAC

success rates. Results: A total of 395 women underwent trial of labour after a single prior CS, with a VBAC success rate of 83%. The Grobman model displayed adequate calibration and the re-calibrated model good calibration with the slope coefficient of 0.87 (95% CI 0.54 – 1.19) and intercept 0.19 (95% CI -0.34 – 0.72). Discrimination was moderate with ROC area of 0.71 (95% CI 0.67 – 0.76). Conclusion: This analysis supports further validation studies in larger Australian settings, and suggests that use of the original Grobman predictive nomogram may be appropriate in Australia.

Introduction:

In Australia, approximately 33% of births are by caesarean section (CS).[1] After one prior CS, women are faced with a decision regarding mode of delivery in each subsequent pregnancy. Both options, elective repeat caesarean section (ERCS) and attempted vaginal birth after caesarean section (VBAC), have potential risks and benefits.

The decision regarding mode-of-delivery is impacted upon by a complex combination of literature suggesting maternal and perinatal morbidity associated with VBAC, individual patient priorities, institutional logistics and liability pressures.[2] Currently, the most common single indication for CS is a prior CS.[3] At present, in Australia, over 80% of women with a history of one previous CS give birth by ERCS.[1] The wider developed world has also seen a significant decrease in the number of women attempting VBAC.[4,5]

Of those women who do attempt VBAC, between 60 – 80% will be successful.[6] The burden of morbidity associated with VBAC is predominantly borne by those women who are unsuccessful [7,8], with particularly serious complications for those who suffer a uterine rupture.[9] However, compared with vaginal delivery, CS is associated with longer recovery, and higher rates of maternal visceral injury, infection, thromboembolic events, and blood loss. Neonatal respiratory distress is also more frequent with ERCS compared with vaginal birth.[10] Each subsequent CS also leads to increased cumulative risk of placenta praevia and placental adhesive disorders in future pregnancies.[11,12] While no VBAC attempt is without risk, if those women with a greater chance of VBAC success can be identified then it may be possible to reduce overall total morbidity by encouraging VBAC in those with the greatest predicted success. Similarly, those women with lesser predicted VBAC success, and higher potential morbidity, can be appropriately counselled.

Thus, in recent times, both antenatal [13] and intrapartum [14,15] prediction models for VBAC success have been developed. Although intrapartum models include significant factors in prediction of VBAC success such as cervical dilatation on presentation, antenatal models have the advantage of allowing appropriate discussion and counselling before labour. The Grobman nomogram [13] can be used at the first antenatal visit to provide an estimation of VBAC success. This model, developed in a United States population, has also been validated in several developed countries [16-19], but not yet in an Australian setting.

Our study aimed to assess the validity of the Grobman [13] prediction model in our regional Australian population.

Materials and Methods:

Women with one previous lower segment transverse caesarean section who attempted VBAC between July 2005 and July 2015 were retrospectively identified via searching the "Birth Outcome Summary" (BOS) database. Prior to study commencement, approval was granted by the Albury Wodonga Human Research Ethics Committee [LNR/15/AWHEC/35]. Women were deemed eligible for inclusion if they had a history of a single prior CS, were between 37 - 42 weeks gestation and were booked to deliver at Wodonga Hospital, Victoria. Women planning an ERCS were excluded. For eligible women, data collection used medical records review to identify outcome (delivery mode), predictive variables used in the Grobman model (maternal age, body mass index (BMI) at booking visit, ethnicity, history of vaginal delivery, history of intervening vaginal delivery since index CS, and indication of prior CS (labour dystocia or obstruction, which were deemed 'recurrent indication for caesarean') and birth weight of the index caesarean delivery. Summary statistics for these baseline variables were presented as mean (SD), median [25^{th} – 75^{th} percentile] or count (%) according to distribution.

We used the modelling framework proposed by Steyerberg et al [20] to both assess the fit of the Grobman [13] logistic model (linear predictor = 3.766 - 0.039*age (years) - 0.06*(BMI) - 0.671 (African-American race) – 0.680 (Hispanic race) + 0.888*any prior vaginal delivery + 1.003* vaginal delivery after caesarean section – 0.632* recurring indication for caesarean) and the requirement for alternative models. Initially, for each woman attempting VBAC, the probability of success was calculated using the Grobman model and an assessment of both calibration, the ability of the model to make unbiased estimates; and discrimination, the ability of the model to separate outcomes were performed. [21]

Calibration was assessed using two methods: the Hosmer-Lemenshow test (HL), formed using chi-squared statistic based upon the deciles of predicted VBAC between expected and observed outcomes outcome; and an assessment of slope and intercept coefficients from a logistic regression model of VBAC outcome against the linear predictor. In this model adequate calibration was reflected in the 95% confidence interval for the slope coefficient covering unity, and the intercept covering zero. The final check of calibration was that the mean predicted probability of VBAC outcome was close to the observed proportion in our cohort. Discrimination was assessed using area under the Receiver Operating Characteristic (ROC) curve.

If the model showed adquate calibration and discrimination then it was considered to be validated for our cohort. If the original model showed poor calibration then a series of sequential models were fitted ranging from recalibration (adjusting the only the intercept so that the mean observed and predicted proportions agree), to re-estimation of the original regression coefficients and finally to the full

development of a new predictive model until adequate fit was obtained. If re-estimation models were required then to improve future prediction a shrinkage factor, weighting regression coefficients back toward the original Grobman coefficients, was used (see Streyerberg for details).[20] The distribution of predicted probabilities was also presented graphically. The significance level was two-sided and set at 0.05. Data were analysed using Stata v14 (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP).

Results

A total of 395 women presenting for a trial of labour after a single prior CS were included in the retrospective analysis. The overall VBAC rate was 328/395 (83%), with 67/395 (17%) requiring an emergency intra-partum caesarean section. There was a past history of vaginal birth in 201/395 (50.9%), and 137/395 (34.7%) had a prior successful VBAC. Table 1 presents summary statistics for baseline covariates, along with the characteristics of the cohort used in construction of the Grobman model. Additional variables, not used in the Grobman model [13], were also collected. For our cohort, the mean infant birth weight was 3530 (SD 483) grams, mean gestation 39 (minimum 37, maximum 42) weeks and cervical dilatation on admission was median 3 [2-5] cm.

When applied to our cohort, the original Grobman model [13] displayed borderline adequate calibration with a HL test p-value of 0.03 and a slope coefficient from the logistic model of VBAC outcome against this model's linear predictor equal to 0.87 (95% CI 0.54 – 1.19) and intercept 0.43 (95% CI -0.03 – 0.88). The lack of fit is confined to 9/395 (2.3%) mothers with predicted probabilities of VBAC less than 0.5 who achieved successful vaginal delivery despite all having a recurring indication for CS and no previous vaginal delivery before or after CS (see figure 1a). The mean predicted probability of VBAC was 79.2% compared to the cohorts VBAC incidence of 83.0%.

A re-calibrated model (see below), adjusting only the intercept so that the mean predicted probability matched the observed VBAC proportion resulted in a well calibrated model. The HL test p-value was 0.06, the intercept 0.19 (95% CI -0.34 – 0.72) and as expected the slope unchanged. In this model only four mothers, all of whom delivered vaginally, had predicted probability of VBAC less than 0.5 (see figure 1b). For both models the Area under ROC curve was 0.71 (95%CI 0.67 – 0.76). Table 2 presents observed outcome and associated 95% confidence intervals based upon deciles of predicted probability for both models.

Re-calibrated Grobman[13] logistic regression equation for Prediction of Achieving VBAC After a Trial of Labor:

Predicted probability of successful VBAC exp(w) / [1 exp(w)], where w = 4.036 – 0.039(age) – 0.060(prepregnancy body mass index) – 0.671(African-American race) – 0.680(Hispanic race) +

0.888(any prior vaginal delivery) + 1.003(vaginal delivery after prior cesarean) – 0.632(recurring indication for cesarean)

Three hundred and twenty two women presented in spontaneous labour (81.5%) and 73/395 (18.5%) women were induced, with either artificial rupture of membranes (ARM) only, or ARM plus oxytocin infusion. There was no significant association between spontaneous labour versus induction of labour and successful VBAC either as unadjusted odds ratios OR 1.19 (95% CI 0.59 to 2.40) or adjusted for the five measured covariates OR 1.01 (95% CI 0.49 to 2.11).

Discussion

Our results suggest that using Grobman [13] variables, the re-calibrated model may be valid for our regional Australian population with a VBAC rate of 83%. Further, the use of the original uncalibrated Grobman nomogram [13] may be useful in predicting VBAC success, especially if VBAC success rates are less than 80%. We note however, even in our cohort with a VBAC success rate of 83% it provided highly useful prediction for probabilities more than 0.5. The original Grobman nomogram [13] only failed in useful prediction when the predicted probability was less than 0.5, where it underestimated VBAC success. This error in prediction is likely due to the small numbers of women with low predicted probabilities.

Australian reports indicate rates of CS delivery continue to climb [1] and numbers achieving VBAC are declining. [4] Internationally, professional colleges have encouraged methods to reduce CS, and endorsed VBAC as safe for most women [4], however favour settings with immediate recourse to emergency CS and neonatal resuscitation. As such, accurate prediction models are potentially of even greater value in these settings without immediate access to emergency delivery means, such as regional Australia.

For the pregnant woman, it is recognised that the maternal morbidity associated with attempted VBAC predominantly lies in the unsuccessful attempt, with emergency CS carrying increased risks compared to elective CS. [8] In addition to this, unsuccessful VBAC is also associated with increased numbers of repeat CS, and thus an exponential increase in risk of placental adhesive disorders. [11] In the setting of uterine rupture, the fetus is at risk of neonatal mortality and long-term morbidity. [9] VBAC is also associated with prolonged gestation compared to ERCS, potentially increasing perinatal morbidity and mortality. With most ERCS performed at approximately 39 weeks, the risks of stillbirth in the postdates pregnancy are effectively negated. These risks must be weighed against the shorter-term risks of RDS in neonates delivered by ERCS. [10]

In recent times, there have been endeavours to develop prediction models to assist women and clinicians in deciding on the safest mode of delivery. If a woman is likely to achieve a successful

VBAC then pursuing a trial of labour is a reasonable option, as long as the fetus is well. On the converse, if a woman is unlikely to be successful, then it may be safer to arrange an ERCS. [14,23] Due to our relatively small data-set, we were unable to establish whether or not lower predicted success rates were linked to higher maternal or neonatal morbidity. [23]

Our rate of successful VBAC (83%) is higher than that reported by Grobman et al [13], as well as greater than reported Australian (25-58%) [24-26], and international VBAC rates for those who labour after one previous caesarean incision (72-75%) [9,25]. This may indicate more stringent selection of VBAC candidates in our local region, and homogenous practices in labour care. It is likely also linked to our service's high vaginal parity rate, with over 50% of women having a history of prior vaginal delivery, and over one third a previous successful VBAC. Thus, external validity to other Australian settings may be limited. A further limitation is our cohort size, which is significantly smaller than other international papers reporting the validity of the Grobman [13] nomogram in their populations.

Our results, using Grobman variables with or without a re-calibrated model, indicate that this predictive nomogram estimating success of a particular VBAC attempt, may have validity in Australian populations. Clearly, further prospective studies should be undertaken to confirm efficacy before widespread adoption in Australian obstetric units. The aim of this report is to support further validation studies in larger Australian settings.

There are no conflicts of interest to report.

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Tables:

Table 1: Cohort characteristics determined at 1st trimester assessment.

Table 2: Observed outcomes and associated 95% confidence intervals based upon deciles of predicted probability.

Figures:

Figure 1: Predicted probability plots for the original Grobman model and the re-calibrated Grobman prediction model; (a) Original Grobman model**,** and (b) Re-calibrated Grobman model

References:

1. Li, Z., Zeki, R., Hilder, L., Sullivan, A.E. Australia's Mothers and Babies 2011. Perinatal Statistics Series no. 28. Cat. no. Per 59. Canberra: AIHW National Perinatal Epidemiology and Statistics Unit, 2013.

2. Guise, J.M., Denman M.A., Emeis, C., et al. Vaginal birth after cesarean: new insights on maternal and neonatal outcomes. Obstetrics and Gynaecology 2010; 115(6), 1267 - 1278.

3. Lee, Y., Roberts, C., Patterson, J., et al. Unexplained variation in hospital caesarean section rates. Medical Journal of Australia 2013; 199: 348 – 353.

4. Cunningham, F.G., Bangdiwala, S., Brown, S.S., et al. National Institutes of Health Consensus Development Conference Statement: Vaginal Birth After Cesarean: New Insights. Obstetrics & Gynecology 2010; 115(6): 1279 - 1295.

5. Martin, J.A., Hamilton, B.E., Sutton, P.D., et al. Births: Final Data for 2007. National Vital Statistics Reports 2010; 59(1):1, 3-71.

6. American College of Obstetricians and Gynecologists. ACOG Practice bulletin no. 115: Vaginal birth after previous cesarean delivery. Obstet Gynecol 2010; 116:450.

7. Pallasmaa, N., Ekblad, U., Aitokallio-Tallberg, A., et al. Cesarean delivery in Finland: maternal complications and obstetric risk factors. Acta Obstet Gynecol Scand 2010; 89(7): 896-902.

8. Allen, V.M., O'Connell, C.M., Liston, R.M., Baskett, T.F. Maternal morbidity associated with cesarean delivery without labor compared with spontaneous onset of labor at term. Obstetrics & Gynecology 2003; 102(3): 477-482.

9. Landon, M.B., Hauth, J.C., Leveno, K.J., et al. for National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. Maternal and perinatal outcomes associated with a trial of labor after prior cesarean delivery. N Engl J Med 2004; 351(25): 2581-2589.

10. Scott, J.R. Vaginal Birth After Cesarean Delivery: A Common-Sense Approach. Obstetrics and Gynaecology 2011, 118(2): 342-350.

11. Silver, R.M., Landon, M.B., Rouse, D.J., et al. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstetrics and Gynaecology 2006; 107(6): 1226-1232.

12. Bowman, Z.S., Eller, A.G., Bardsley, T.R., et al. Risk factors for placenta accreta: a large prospective cohort. Am J Perinatol 2014; 31(9): 799-804.

13. Grobman, W., Lai, Y., Landon, M.B., et al. Development of a Nomogram for Prediction of Vaginal Birth After Cesarean Delivery. Obstetrics and Gynaecology 2007; 109(4): 806-812.

14. Grobman, W.A., Lai, Y., Landon, M.B., et al, for Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. Can a prediction model for vaginal birth after cesarean also predict the probability of morbidity related to a trial of labor? Am J Obstet Gynecol 2009; 200(1): 56.e1-56.e6.

15. Metz, T.D., Stoddard, G.J., Henry, E., et al. Simple, Validated Vaginal Birth After Cesarean Delivery Prediction Model for Use at the Time of Admission. Obstet Gynecol 2013; 122(3): 571-578.

16. Chaillet, N., Bujold, E., Dubé, E., and Grobman, W. Validation of a Prediction Model for Vaginal Birth After Caesarean. J Obstet Gynaecol Can 2013; 35(2): 119–124.

17. Annessi, E., Del Giovane, C., Magnani, L., et al. A modified prediction model for VBAC, in a European population. J Matern Fetal Neonatal Med 2016; 29(3): 435-439.

18. Schoorel, E.N., Melman, S., van Kuijk, S.M., et al. Predicting successful intended vaginal delivery after previous caesarean section: external validation of two predictive models in a Dutch nationwide registration-based cohort with a high intended vaginal delivery rate. BJOG 2014; 121(7): 840-847.

19. Fagerberg, M.C., Maršál, K., and Källén, K. Predicting the chance of vaginal delivery after one cesarean section: validation and elaboration of a published prediction model. Eur J Obstet Gynecol Reprod Biol 2015; 188: 88-94.

20. Streyerberg, E., Borsboom, G., van Houwelingen, H., et al. Validation and updating of predictive logistic regression models: a study on sample size and shrinkage. Statistic in Medicine 2004; 23: 2567 - 2586.

21. Harrell, F.E. Multivariable Modeling Strategies. In: Regression Modeling Strategies with applications to linear models, logistic and ordinal regression, and survival analysis. 2nd edn. New York: Springer; 2015; 75 – 78.

22. Gonen, R., Tamir, A., Degani, S., and Ohel, G. Variables associated with successful vaginal birth after one cesarean section: a proposed vaginal birth after cesarean section score. Am J Perinatol 2004; 21(8): 447 - 453.

23. Chaillet, N., Bujold, E., Dubé, E., and Grobman, W. Validation of a Prediction Model for Predicting the Probability of Morbidity Related to a Trial of Labour in Quebec. J Obstet Gynaecol Can 2012; 34(9): 820-825

24. Appleton, B., Targett, C., Rasmussen, M., et al. Vaginal birth after Caesarean section: an Australian multicentre study. VBAC Study Group. Aust N Z J Obstet Gynaecol. 2000; 40(1): 87-91.

25. Royal College of Obstetricians and Gynaecologists. Birth after Previous Caesarean section. 2015. [cited 2016 December 12]. Available from: https://www.rcog.org.uk/globalassets/documents/guidelines/gtg_45.pdf

26. Crowther, C.A., Dodd, J.M., Hiller, J.E., et al. Planned vaginal birth or elective repeat caesarean: patient preference restricted cohort with nested randomised trial. Birth After Caesarean Study Group. PLoS Med. 2012; 9(3):e1001192. doi:10.1371/journal.pmed.1001192

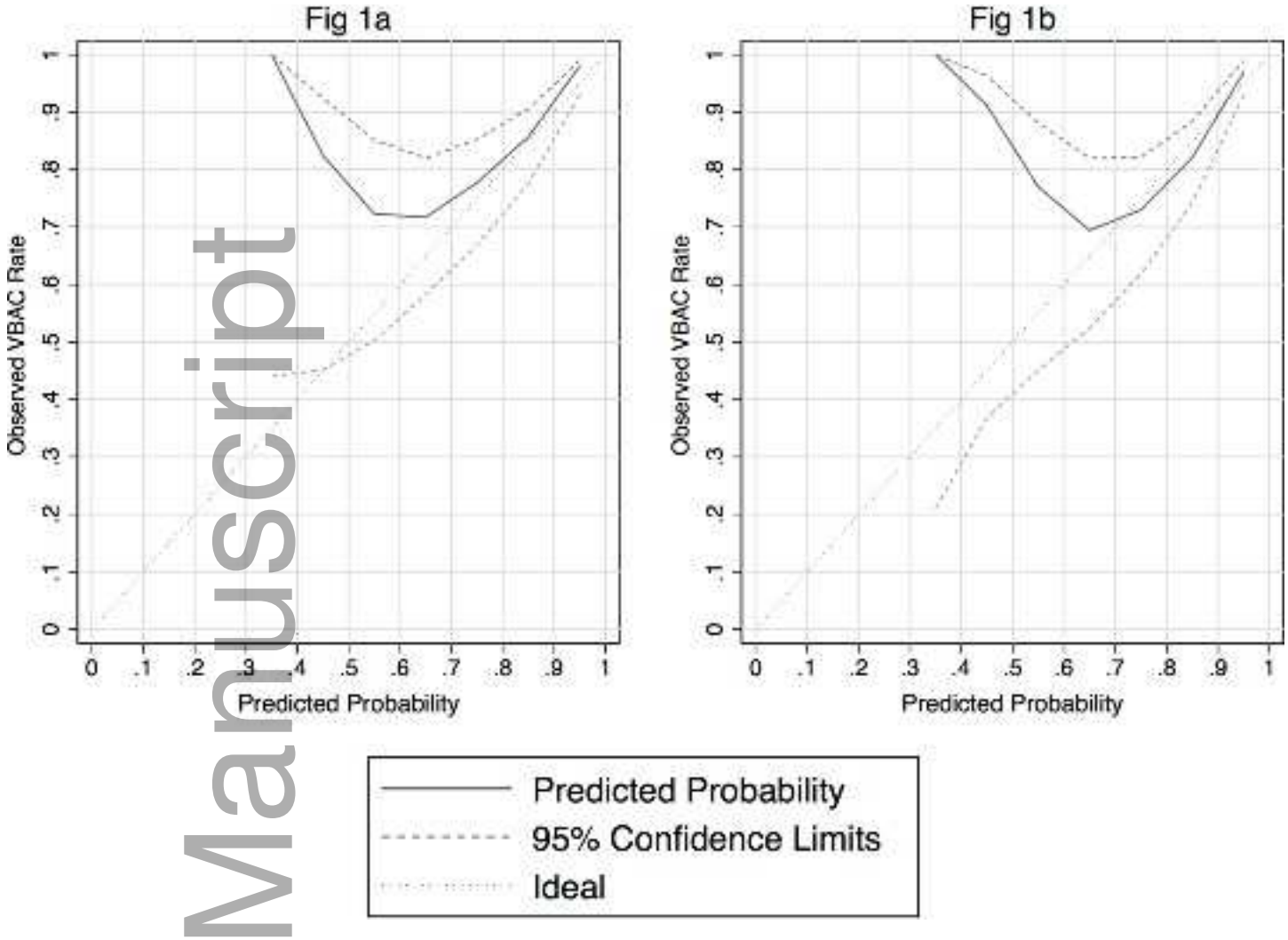
Table 1 Cohort characteristics determined at 1st trimester assessment.

	Study (n = 395)	Grobman* (n = 11,856)
VBAC rate	328 (83.0%)	73.0
Age (years +/- SD)	31.2 +/-5.0	28.6 +/-5.8
BMI ($kg.m^{-2}$ +/- SD)	26.3 +/- 5.6	26.4 +/- 6.3
Recurrent indication for delivery (number %)	103 (26.1%)	36.3
Any prior vaginal delivery	201 (50.9%)	47.5
Previous VBAC	137 (34.7%)	33.7
Ethnicity		
Caucasian	361 (91.4%)	38.7
Afro-american	4 (1.0%)	19.9
Hispanic	0	36.3
Other	30 (7.6%)	5.1
Years since delivery by CS (years +/- SD)	4.7 +/- 3.5	5.2 +/- 3.6
Maximum prior birth weight (grams +/- SD)	3181 +/- 722	3996 +/- 680

* Grobman model based upon subset of 7660 women with complete data

Table 2: Observed outcomes and associated 95% confidence intervals based upon deciles of predicted probability.

Deciles based upon models predicted probability	Grobman Prediction Model		Re-calibrated Grobman model	
	Successful VBAC/Attempted VBAC	VBAC rate (95%CI)	Successful VBAC/Attempted VBAC	VBAC rate (95%CI)
0.0 – 0.1	-	-	-	-
0.1 – 0.2	-	-	-	-
0.2 – 0.3	-	-	-	-
0.3 – 0.4	4/4	1 (0.44 – 1)	1/1	1 (0.21 – 1)
0.4 – 0.5	5/6	0.83 (0.44 – 0.97)	4/4	1 (0.44 – 1)
0.5 – 0.6	23/36	0.64 (0.48 – 0.78)	9/13	0.69 (0.42 –0.87)
0.6 – 0.7	39/53	0.74 (0.60 – 0.84)	29/44	0.66 (0.51– 0.78)
0.7 – 0.8	71/95	0.76 (0.66 – 0.83)	66/88	0.75 (0.65 – 0.83)
0.8 – 0.9	67/80	0.84 (0.75 – 0.90)	73/94	0.77 (0.68 – 0.85)
0.9 – 1	118/121	0.98 (0.93 – 0.99)	146/151	0.97 (0.93 – 0.99)



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