Calving performance after embryo transfer-induced twinning - a summary of 30 studies

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ABSTRACT

Twin calving in beef cows has been proposed as a strategy to increase the biological as well as economic efficiency of beef production. The aim of this paper is to summarise the calving performance of cows induced to calve twins following embryo transfer using data from 30 published studies. The pooled data shows that 45, 28 and 27% of recipients give birth to either 0, 1 or 2 calves resulting in 82 calves born/100 recipients and 47% of calving cows producing twins. Overall mean embryo survival rate was only 41%. Compared with recipients which received *in vitro*-produced embryos, a higher proportion of recipients that received either a pair of *in vivo*-derived embryos or a single such embryo in conjunction with AI were pregnant (60 vs 43%) or produced twin calves (52 vs 39%). In addition, more calves were born (90 vs 60%). Considerable variation exists in all parameters, particularly the proportion of number of calves born.

Keywords: twin-calving; beef cows; embryo transfer; embryo survival.

INTRODUCTION

The life cycle efficiency of beef production is closely related to reproductive rate (Davis *et al.*, 1983 b, 1984). It follows that an increased frequency of twin calving should increase the efficiency of beef production. Simulation studies have indicated a 20-30% increase in both the biological as well as economic efficiency of beef production systems incorporating twin calving cows (Guerra-Martinez *et al.*, 1987; Herd *et al.*, 199; Morris *et al.*, 1994).

Twin calving can be achieved by a number of means. The incidence of spontaneous twin calving in cattle is generally less than 5% (Morris, 1984). As a consequence, it is unlikely to provide a practical means of increasing beef productive efficiency in the foreseeable future. Twin calving can be induced by increasing ovulation rate (Gordon *et al.*, 1962; Bindon and Hillard, 1992). This approach has not found widespread acceptance due to highly variable ovulation and calving rates. The third means involves embryo transfer. With this approach, either a pair of embryos are transferred or a single embryo is transferred to a previously inseminated cow. Outcomes following this embryo transfer approach have been the most widely reported.

The aims of this study are to summarise the reproductive performance of cattle induced to twin calve following one attempt using embryo transfer. Estimates of mean performance as well as variability are presented. It is important to highlight that a high level of reproductive performance was not necessarily the goal in all studies. In many studies involving experimental embryo treatments (e.g., nuclear transfer, demi-embryo transfer, *in vitro*-produced embryos), twin rather than single embryos were transferred to maximise the use of available recipients.

MATERIALS AND METHODS

A total of 30 published papers were selected from within the international literature because they met the criteria of inducing twin calving using embryo transfer and presented calving data for these recipient cows. From these papers, the following parameters were extracted:

- number of recipients
- percentage of recipients with 0, 1 or 2 calves born
- embryo survival rate (% calves born/embryo, ESR)
- pregnancy rate to calving (% cows calving/recipient, PR)
- twin calving rate (% calving twins/cows calving, TR)
- calving rate (% calves born/recipient, CR)

A total of 85 estimates of these parameters were available since most papers permitted the extraction of more than one estimate. From these estimates, the unweighted mean and variation were estimated. Variation was expressed in four ways: minimum, maximum, standard deviation and coefficient of variation using standard formulae in the Microsoft Excel software package. Rounding error may cause some slight difference in coefficient of variation estimates derived manually from Table 1 and 2. Pooled estimates as well as estimates derived from classifying the data into one of four groups are presented: two *in vivo*-derived embryos transferred (MOET); two *in vitro*-produced embryos transferred (IVP); a single *in vivo*-derived embryo transferred to a previously artificially inseminated cow (MOET + AI); and a miscellaneous group (MISC) comprising *in vivo*-derived demi-embryos, nuclear transfer IVP embryos, (IVP + AI) embryos and data from a herd receiving a mixture of MOET and MOET + AI embryos.

RESULTS

Number of recipients

A total of 4,482 recipients were involved in the analyses. The number of recipients per estimate was 53, although this ranged from 2-541.

TABLE 1: Mean and variation in number of recipients and reproductive performance (pooled data).

	No. of Recipients	% Recipients with 0, 1 or 2 calves born:			ESR[1]	PR[1]	TR[1]	CR[1]
		0	1	2				
Mean	53	45	28	27	41	55	47	82
Minimum	2	0	0	0	13	25	0	25
Maximum	541	75	60	100	100	100	100	200
Standard Deviation	-	16	11	15	14	16	19	28
Coefficient of Variation , %	-	34	40	56	35	28	40	35

[1] embryo survival rate, pregnancy rate, twinning rate, calving rate

Recipients with 0, 1 or 2 calves born

Overall, 45 ± 16% (mean ± s.d.) of recipients failed to produce calves with a range from 0-75%. The coefficient of variation was 34%. The mean percentage of recipients with a single calf was 28 ± 11%. Three estimates involving a total of 26 recipients yielded no single calves. A maximum of 60% of the recipients produced a single calf in one study (from a total of 15 recipients). A mean of 27± 15% of recipients produced twin calves. In 3 estimates, no twin calves were born from a total of 19 recipients. All 5 recipients produced twins in one estimate. However, this was an extreme result in that the next 6 highest estimates ranged from 50-56% (98 recipients). Variation, as measured by standard deviation estimates, were lowest for the proportion of recipients calving a single calf (11%) and similar for the remaining two proportions (about 16%).

Embryo survival rate (ESR)

Overall, only 41 ± 14% of embryos were represented by calves at term. In two estimates involving a total of 7 recipients, ESR was less than 20%. All embryos survived in one estimate involving 5 recipients. The next 4 highest estimates ranged from 60-75% (110 recipients).

Pregnancy rate (PR)

Overall, 55 ± 16% (mean ± s.d.) of recipients produced a calf or calves with a range from 25-100%. The percentage of pregnant recipients is the difference between 100% and the percentage of recipients giving birth to no calves. Since the results for the percentage of recipients giving birth to no calves has been presented previously, the reader is referred to that section of the paper.

Twin calving rate (TR)

Of the recipients which calved, almost half delivered twins (47 ± 19%). As mentioned previously, three estimates produced no twins. At the other extreme, three estimates produced a 100% TR (26 recipients). The next 3 highest estimates produced an 80-90% TR (43 recipients).

Calving rate (CR)

Overall, 82 ± 28 calves were born per 100 recipients from a single attempt at induced twinning. In two estimates, CR was lower than 40% (5 recipients). At the other extreme, CR was 200% and 150% in two estimates involving a total of 7 recipients. The next three highest estimates ranged from 121-127% (108 recipients).

MOET, MOET + AI, IVP and MISC data (Table 2)

The mean reproductive performance of MOET and MOET + AI recipients and embryos was similar for all 5 parameters examined. Mean performance in IVP and MISC recipients was similar, although lower than for the other two groups. For example, mean ESR and PR and TR was about 15 percentage units lower, and CR about 30 percentage units lower (90 vs 61%).

Variation between estimates as measured by their standard deviation was similar for MOET and MOET + AI recipients and embryos. In general, variation in performance was less for IVP compared with MISC recipients and embryos. Within each of the four groups, variation in ESR was lower than for PR and TR, and variation in CR was consistently the highest.

DISCUSSION

The results demonstrate that twin calving rates in the order of 50-60% can be achieved by using an embryo transfer approach with embryos derived by *in vivo* methods. Similar outcomes are expected for scenarios using either two such embryos or a single embryo in conjunction with AI. However, it is clear that considerable variation exits between different estimates of twin calving rate. It is interesting to compare this 50-60% twin calving outcome with that achieved in other species. For example, in spontaneously multiple ovulating sheep which lamb, the mean twin lambing rate is 62% (Davis *et al.*, 1983 a). For twin ovulating ewes which lamb, 70% deliver twin lambs (Kelly, 1982). These apparently higher twinning rates in multiple ovulating sheep suggest that sheep are inherently more capable of twin pregnancies than are cattle. However, in spontaneously twin ovulating cows which calve, 62% have been reported to deliver twins (Echternkamp *et al.*, 1990), thus refuting this proposition of higher twinning potential in sheep compared with cows. The lower twin calving rates in recipients receiving a pair of *in vitro*-produced embryos suggests that such embryos are of lower quality than *in vivo*-produced embryos. Recent evidence comparing survival rates of the two types of embryos in the same experiment support this conclusion (Sinclair *et al.*, 1995).

An important finding in this paper is the low overall embryo survival rate to term (30-46%) compared with single embryo transfer studies. Even with embryos produced by classical superovulation-embryo recovery-embryo transfer techniques (i.e., *in vivo*-produced embryos), fewer than half of the twin-transferred embryos were represented by calves at term. With *in vivo*-produced embryos, survival rates of 60-70% have been reported following single embryo transfer (Hasler *et al.*, 1987). In the case of embryos produced by *in vitro* methods, only 3 in 10 resulted in calves. Survival rates of 45-60% have been reported for *in vitro*-produced embryos transferred as

singles (Hasler *et al.*, 1995). One possible explanation is that the transfer of two embryos rather than one compromises overall survival rate. The evidence in cattle suggests that this is not the case when single and twin embryo transfers have been compared in the same study (McMillan *et al.*, 1994; McMillan, 1995).

The results demonstrate that twin embryo transfer does not increase pregnancy rates above that expected with single transfers. Expressed another way, 40-57% of recipients would be expected to produce no calves after one attempt at twin embryo transfer. In practice, these recipients could be joined with the bull or submitted for AI and could result in final overall calving rates for the herd of over 110%. Alternatively, they could undergo further programming for twin embryo transfer resulting in a mean 95-125% calving rates after two atempts.

The net outcome of one round of transfer of *in vivo*-derived embryos was an increase in the number of calves born to about 90 per 100 recipients (i.e., twice the embryo survival rate). The *in vitro*-produced embryos and the miscellaneous embryos (MISC) resulted in only normal calving rates (about 60%). The high standard deviations associated with these means indicates that in about two thirds of cases, the outcome will be within 20% of the expected mean.

CONCLUSION

In conclusion, further research is required to ensure that not only are higher embryo survival, and therefore higher calving rates achieved, but that embryo quality is more consistent. Attention to both embryo as well as recipient factors are required to achieve this goal.

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TABLE 2: Mean and variation in number of recipients and reproductive performance (classified by embryo description).

Embryo Description[1]		Mean	Minimum	Maximum	Standard Deviation	Coefficien of Variation
MOET	No. Recips.	38	2	115	-	-
(27 estimates, 1028 recips.)	% recipients with 0 CB[2]	41	0	68	16	38
	% recipients with 1 CB	26	0	60	13	51
	% recipients with 2 CB	33	14	56	12	37
	ESR[3]	46	23	75	12	27
	PR[3]	59	32	100	16	27
	TR[3]	56	31	100	18	32
	CR[3]	91	46	150	24	27
IVP	No. Recips.	51	4	109	-	-
(13 estimates, 657 recips.)	% recipients with 0 CB	57	40	75	10	18
	% recipients with 1 CB	26	10	39	8	31
	% recipients with 2 CB	17	0	40	9	52
	ESR	30	13	45	9	29
	PR	43	25	60	10	23
	TR	39	0	80	18	46
	CR	60	25	90	18	29
MOET + AI	No. Recips.	64	4	541	-	-
(33 estimates, 2106 recips.)	% recipients with 0 CB	40	0	65	14	34
	% recipients with 1 CB	30	0	50	11	38
	% recipients with 2 CB	30	9	100	16	55
	ESR	45	25	100	14	31
	PR	60	35	100	14	23
	TR	48	17	100	17	34
	CR	89	50	200	28	31
MISC	No. Recips.	58	3	241	-	-
(12 estimates, 691 recips.)	% recipients with 0 CB	54	28	72	16	30
	% recipients with 1 CB	29	16	44	9	31
	% recipients with 2 CB	17	0	44	14	82
	ESR	31	17	58	14	46
	PR	46	28	72	16	36
	TR	34	0	62	20	59
	CR	62	33	116	29	46

[1]refer to text for description, [2] calves born, [3] embryo survival rate, pregnancy rate, twinning rate, calving rate

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