

other feedback, coupled with a subject's dynamic learning, can compensate for inaccuracies in the model to provide an easily and voluntarily adjusted control signal. Our results demonstrate that a simple mathematical approach, coupled with a biological system, can provide effective decoding for brain-machine interfacing, which may eventually help to restore function to neurologically impaired humans.

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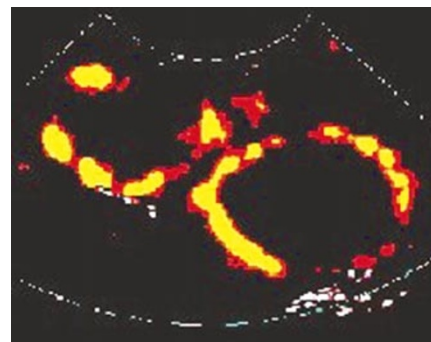
Sonography

## Dizygotic twin survival in early pregnancy

It has been suggested that losses of twin conceptuses in very early pregnancy are high, and that for every liveborn twin pair there are a further 10–12 twin pregnancies that end up as a singleton birth<sup>1</sup>. Here we show that in a group of women who had double-ovulated and conceived, the probability of the second egg also becoming fertilized and developing is 20–30% — which is comparable to the probability of conception and survival of a single conceptus<sup>2</sup>. We conclude that the presence of one embryo does not affect the development of its twin.

So far, no direct measure has been available of the proportion of double ovulations that lead to twins. We have obtained this information by using ultrasound to identify pregnant women with two corpora lutea, and correlating these with the number who had one or two fetuses (dizygotic twins) in early pregnancy. The corpus luteum is an endocrine organ that develops in the ovary at the site at which the egg was released, and can therefore act as an indicator of the number of ovulation events.

As only two small ultrasound studies have identified the corpus luteum in early pregnancy<sup>3,4</sup>, we confirmed these findings in a larger series at our centre, where the ovaries of all pregnant women are routinely examined. We scan mainly low-risk pregnancies,



**Figure 1** Doppler ultrasound of two corpora lutea in one ovary (signifying dual ovulation). The corpus luteum typically appears as an echo-filled cyst with a ring of peripheral vascularity. Colours reflect variations in blood flow, with yellow as the fastest.

as well as women who had assistance in conceiving. In scans of 504 women where both ovaries were seen in early pregnancy (5–9 weeks gestation), the corpus luteum could be identified in 94.6% of cases. Its mean diameter was 19.6 mm ( $\pm 5.28$  standard deviation). Single ovulations were distributed equally between the two ovaries, occurring on the left in 49.3% of cases.

There were 48 cases of double ovulation identified by these ultrasound scans (Fig. 1). Of these (Table 1), 27 were spontaneous, with 9 among this group conceiving twin pairs (30%) and the remainder singletons. Fifteen double ovulations were induced by clomiphene citrate, and among these there were three sets of twins (20%). We were unable to determine whether the dual ovulation was spontaneous or induced in the remaining six cases, of which three were twin pregnancies. Maternal age among those who had double-ovulated (32.5 years) was not significantly different from those who had had a single ovulation (30.7 years;  $P=0.07$ ,  $t$ -test). All sets of twins were of dichorionic and diamniotic placentation on ultrasound examination, which is consistent with dizygotic twinning.

We conclude that the presumption of

huge losses of dizygotic twins in early pregnancy<sup>1</sup> is unfounded, as we would then have seen many more double ovulations with a singleton-pregnancy outcome (signifying an aborted twin). The probability of the second egg also becoming fertilized seems to be similar to that of one egg becoming fertilized in a singleton pregnancy<sup>2</sup>. The presence of one embryo therefore does not impede the development of its twin.

Our study does not, of course, eliminate the possibility that both twins might be lost at a higher rate than singletons. However, we do not believe that this would fit with our finding that the second egg has the same chance of developing as a singleton pregnancy once the first egg is fertilized.

The distribution of spontaneous double ovulations is consistent with a random spread of ovulation between left and right ovaries (Table 1). This suggests that the mechanism responsible for dual ovulation involves signalling from outside the ovary, rather than local intra-ovarian control<sup>5</sup>, as we would then have seen more double ovulations from the same ovary.

We have confirmed that the corpus luteum can be readily identified in an early-pregnancy scan, enabling us to characterize a significant number of double ovulations in the human. To our knowledge the last attempt to do this was in 1794, when William Hunter observed after 400 dissections of pregnant uteri: "When there is one child, there is only one corpus luteum; and two in the case of twins. ...In some of these cases, there were two distinct corpus lutea in one ovarium."<sup>6</sup>

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**Table 1** Distribution of double-ovulation events

	Both left	One in each	Both right
Spontaneous	7	14	6
Iatrogenic	2	6	7
Unknown	3	3	0
Total	12	23	13

Forty-eight cases of double ovulation were identified by ultrasound scans of 504 women during early pregnancy. Of these cases, 27 were spontaneous, resulting in 9 sets of twins and 18 singletons; and 15 were induced, resulting in 3 twin pairs.