DDRC Healthcare – Diving, Menstruation and Reproductive Health

Compiled by the DDRC Healthcare Research Team

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This presentation has been put together by DDRC Healthcare. It focuses on issues around menstruation, pregnancy and diving.

Diving, Menstruation and Reproductive Health

Three commonly asked questions:

1. DCI risk differences between the sexes - are women more susceptible than men to DCI?
2. The menstrual cycle and DCI - is there an effect of the menstrual cycle on DCI risk?
3. Pregnancy - can I dive whilst pregnant: risk to the foetus?

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There are three principal questions surrounding the subject of women and diving.

1. Are women more susceptible than men to DCI risk?
2. Is there an effect of the menstrual cycle on DCI risk?
3. Should I dive whilst pregnant?

DCI Risk: Men vs Women

- Early altitude studies were inconclusive, controversial, and not always in agreement.
- Later diving and altitude studies tend to agree.
- Broadly speaking, women do not appear to be more at risk of DCI when compared with men for similar diving habits.

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The debate surrounding men and women and the risk of DCI has been on-going since the early 1970's with both diving and high-altitude studies discussed at length. However, many of the data sets, methodologies, and environments studied have all differed hugely, with some studies based on retrospective records, some with incomplete data, or some with gender not even considered the main reason for the study. As a result, many of the study findings are inconclusive or controversial.

Early *altitude* DCI studies appeared to show an increased altitude DCI risk in women compared with men, which triggered much debate. Sometimes the arguments concerned the methodologies, and sometimes about the analysis. In more recent years however, well controlled studies have definitely *not* found a female risk for altitude DCI when compared with males for the *same* exposures.

In the early *diving* studies, the methodologies and dive profiles in the available observable data made it almost impossible to draw *firm* conclusions regarding the effect of sex on diving DCI risk. But data from the larger more recent studies appears to agree with the later well controlled altitude studies, and show that there is *no difference* in risk of diving DCI between the sexes

So - *very broadly* speaking, women do not appear to be more at risk of diving DCI when compared with men for *similar* diving habits.

The Menstrual Cycle

Between the 1970s and up to 1998 studies showed there might be a possible relationship between the menstrual cycle and DCI – both altitude and diving studies.

These findings were often mis-quoted.

Between 1998 and 2006 more structured studies from both altitude and diving environments began to show there may be a relationship between DCI and *time* over the 28 days in the menstrual cycle.

They found that DCI risk was slightly high during menstruation (week 1 of the cycle) compared to mid cycle, around week 3.

This applied most notably to those NOT on the oral contraceptive pill (OCP).

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Between the years of 1978 and 1998 there was an awful lot of debate and a great flurry of research projects, both altitude and diving, that attempted to prove or disprove any relationship between the M/C and DCI.

As with the older studies, many of the diving M/C studies were retrospective (looking back over old records) and as a result the data were deemed unreliable.

Then from about 1998 more structured studies from both altitude and diving began to show there may be a relationship between DCI incident/risk and the *time* in the M/C over a typical 28-day cycle, particularly in those who were NOT taking the OCP.

The Menstrual Cycle

How reliable were these later studies?

- Only diagnosed and treated in a chamber
- Exact time in the menstrual cycle that DCI occurred
- OCP vs non-OCP
- Diving and menstrual diary data
- >50,000 dives and 11,000 cycles
- Military data

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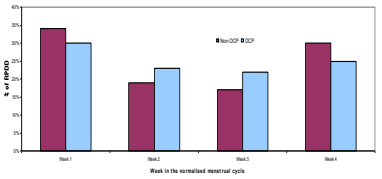
The studies after 1998 were from much more reliable data than previously gathered. They only used data where it was known that the diver had been diagnosed and treated in a chamber for DCI, the exact time in the menstrual cycle of the DCI, *and* if they were on the OCP or not. In other words, researchers did not rely on the vague recall of "I didn't have a period that week because I remember we went away for the week-end" type of data!

In a separate research study, which ran alongside the DCI studies, divers were asked to keep diving diaries for up to three consecutive years to observe any problems they may have had during a dive to see how it might relate to the time in the menstrual cycle. The data from this study of over 50,000 dives and more than 11,000 menstrual cycles proved invaluable in backing up the findings of the diving and altitude studies. In the case of the altitude studies, most came from the US Air Force, so these data were very reliable indeed.

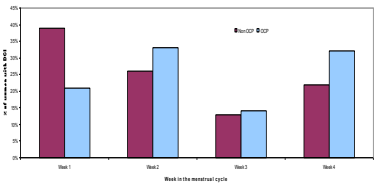
The Menstrual Cycle

Reported incidents of DCI over the four weeks of the M/C

DDRC study normalised data



The Lee study 2003 normalised data

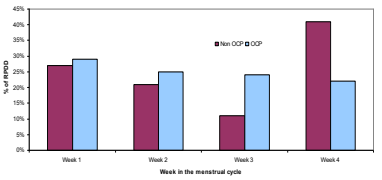


Results from different studies:

The non-OCP (purple bars) incidents of DCI show similar trends, with fewer DCI in the third week (mid cycle).

The OCP (blue bars) do not show any definitive or significant trend, and this was because we observed that divers were taking the OCP to fit in with their social life.

DDRC data 28 day cycles only



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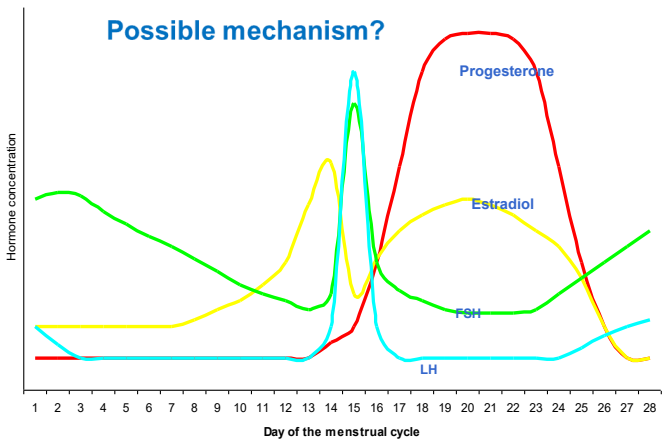
In this series of charts, it shows the four weeks of the menstrual cycle together with diagnosed DCI from different types of analysis and different data sets. The blue bars show those who were on the OCP, the purple/red bars show those NOT on the OCP.

If there was *no* relationship between the menstrual and DCI, you would expect the incidence of DCI to be evenly distributed over 28 days – but what is so interesting about the different research results is that *all* the studies broadly showed the same trends. Which-ever way the data were analysed - the incidence of DCI was *not* evenly distributed over the four weeks of a typical 28-day menstrual cycle – and this applied most especially to those who were NOT on the OCP.

As you can see the risk of DCI appeared to be greater in the first week of the cycle (i.e. during the period), falling to the lowest risk in week three (mid cycle), before rising again in week four (before the next period)

If you look at the blue bars it shows the OCP findings were much *less* clear and not at all consistent in their results.

The Menstrual Cycle



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And now look at this diagram of the hormone changes over a typical menstrual cycle, with the average research results of the DCI risk – it shows us that the cycle, and the potential effects on DCI risk is very complex!

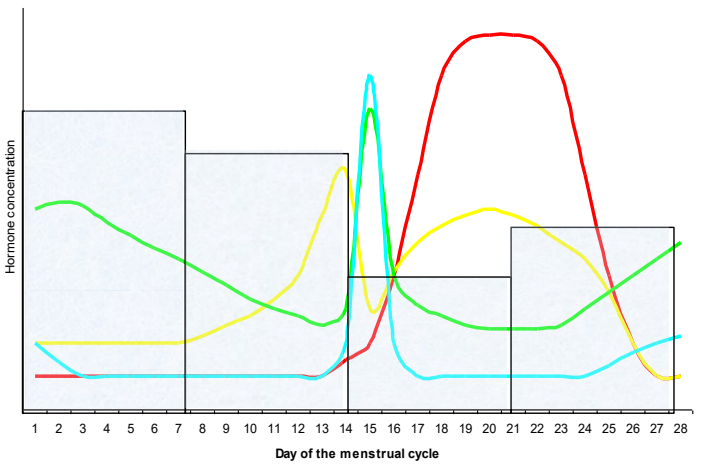
It indicates more *formal* research is needed to establish a greater understanding of the subject.

So, the question remains: if there is an effect of hormones on the DCI risk, is there a protective effect (i.e. DCI risk is lower in week 3) - or is there a risk effect (i.e. DCI risk is higher in weeks 1 and 4) ?

Unfortunately, the practicalities of taking a very large number of people and investigating the relationship between the menstrual cycle and DCI risk is huge and expensive; and they would have to be “dived” many times in a chamber under very controlled conditions during a menstrual cycle and over quite a number of menstrual cycles each.

So, we may never actually know the true answer to the question!

The Menstrual Cycle



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A chance here for the audience to debate the issue……perhaps…….

Oral Contraceptive Pill

- Someone on the OCP has a pharmaceutically driven menstrual cycle.
- The debate surrounding the OCP and DCI risk is inconclusive, and research results are not always in agreement.
- This is due to the variations in methodologies, types of OCP, missing information, and differences in analysis.
- ...It is problematical to say the least!

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People on the OCP don't have the same extreme hormone fluctuations as those *not* taking the OCP – instead, they have what is known as a pharmaceutically driven cycle.

Many researchers and medical personnel have tended to assume that everyone religiously takes the OCP as instructed on the packet – and as a result some of researchers have assumed that everyone in a study, from retrospective records or field studies, would have a 28-day cycle. In reality this is not the case.

This assumption has just helped to further cloud the OCP and DCI risk issue thus fuelling the debate, with different methodologies and analysis being used - added to which some retrospective studies have suffered from missing data – so you start to see the problem!

Oral Contraceptive Pill

- Research by DDRC showed that people use the OCP to avoid a bleed to suit their social and work lifestyles, therefore shortening (21 days) or lengthening (60 days) the cycle for their own convenience.
- The debate regarding the DCI risk with use of the OCP is ongoing.
- It will remain unclear until OCP usage is more accurately recorded in diving research studies.

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Many people clearly use the OCP for their own convenience – either shortening or lengthening the cycle to suit their life-styles, according to whether they have a “hot date”, a weekend on the boat with zero privacy, or a dive holiday planned.

In fact, some DDRC research showed that OCP M/Cs were as short as 21 days or as long as 60 days – so it makes it very difficult to come to any definitive conclusions on the subject of OCP and DCI risk. It is obvious that any research aimed at evaluating the risk of DCI and the OCP would need to be very accurately recorded indeed!

So the jury is still out on this one…..

Pregnancy

There is no *conclusive* evidence that diving whilst pregnant causes harm to mother or baby.

However, there *is* some anecdotal and limited evidence that diving increases the risk of miscarriage, and there is a theoretical risk that DCI (and recompression treatment) may be harmful to a foetus.

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Now for the subject of diving and pregnancy.

Pregnancy

Foetal circulation differs from the adult…

In the adult circulation blood travels through the lungs, where small bubbles are filtered out and removed before the blood is pumped around the body.

In the foetus the circulation bypasses the lungs, meaning bubbles could pass into the arteries, be carried around the body and be potentially life threatening.

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Put very simply, the foetal circulation differs from the adult. In the adult almost all the output from the heart travels through the lungs where small bubbles are removed.

In the foetus the circulation bypasses the lungs so any bubble that forms in the unborn child could be potentially life threatening.

Pregnancy

- Studies to determine the safety of diving during pregnancy are very limited.
- Studies on animals have been contradictory.
- Human retrospective studies (questionnaires) have suffered from small numbers and problems with methodology.
- A study by DDRC (2006) showed that even though 129 participants reported 157 pregnancies with 1465 dives, no conclusions could be reached regarding problems when diving whilst pregnant.

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Human studies have not really provided the answer, as these must take the form of retrospective questionnaire research – and this is not always a reliable method of research since people cannot always recall events accurately.

A large study by DDRC in 2006 found that no conclusions could be reached about the safety of diving whilst pregnant.

Due to lack of conclusive research it is *not* possible to recommend or establish safe limits to dive whilst pregnant.

Why is there no conclusive research? - It would be unethical to conduct a trial that could result in harm to mother and baby.

Pregnancy

To detect a statistical meaningful increase in birth defects from diving whilst pregnant…

4,000 people would need to dive all the time during pregnancy.

Clearly this is not ethical or feasible!

In fact, statistical analysis shows that 4000 pregnant divers would be needed to dive consistently to certain depths all the way through their pregnancies – from start to finish – in order to find answers for safe limits to dive whilst pregnant!

Obviously, this would not be ethical or practical to even try to attempt this kind of research.

Pregnancy

Due to lack of evidence, it is *not possible* to recommend or establish safe limits to dive whilst pregnant.

It is therefore recommended *not to dive* if you are pregnant or trying to get pregnant.

Summary

Research shows:

- Women do *not* seem to be at greater risk of DCI than men for the *same* profiles.
- Some people, *not* on the OCP, may be at a slightly increased risk of DCI during menstruation and a slightly decreased risk mid cycle, although this remains unclear.
- The jury is still out regarding OCP and DCI risk overall.
- It is *not* possible to recommend or establish safe limits to dive whilst pregnant.

7 slides at the end of this presentation contain a comprehensive literature list for discussion and further reading.

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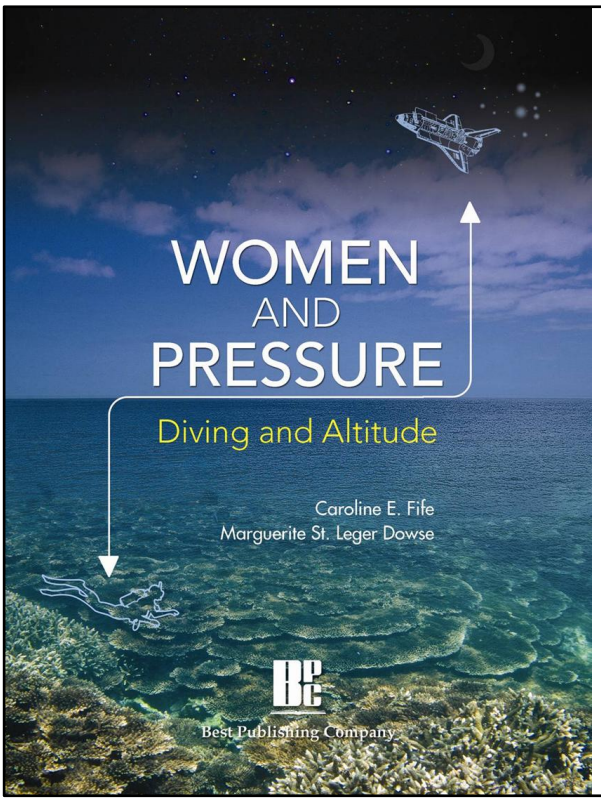
So, in conclusion we can say:

Women do not seem to be at greater risk of DCI than men for the same profiles.

Some women, **not** on the OCP, may be at a greater or lesser risk of DCI over the MC, depending on the time in the MC.

The jury is still out regarding the OCP and DCI risk.

It is not possible to recommend or establish safe limits to dive whilst pregnant – therefore if you are trying to become pregnant, or you are pregnant, and want to be absolutely certain that any problem with the pregnancy or the outcome cannot be attributed to diving – then don't do it…….



Also, further reading:

All the subjects outlined in this lecture are covered in much greater depth in the book *Women and Pressure: Diving and Altitude*

ISBN 978-1-930536-60-9

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In 2010 Caroline Fife of the USA and Marguerite St Leger Dowse compiled a book with information on women in diving or altitude.

All the subjects outlined in this lecture are covered in depth in this book.

The book is available for purchase in hardback or as an eBook online from:

www.amazon.co.uk

www.bestpub.com

Publication Date: **March 9, 2010**

The Literature – Gender Comparisons	Conclusions
Bassett BE. 1973	Altitude. Incidence of DCS in women significantly greater than in men. Data from 3,190 exposures 1968-72. Problems with reporting and selection of subjects.
Bangasser S. 1978	Diving. Incidence of DCS 3.3 greater in women compared with men. 88,028 female estimated dives vs. 43,126 estimated male dives. DCS was "presumed".
Bassett BE. 1980	Altitude. Confirmed the results of 1973. Found a 3.6 fold increased risk of DCS in women compared with men. Data from 2,601 exposures 1973-77. Problems with reporting and selection of subjects.
Waligora JM, Horrigan D, Conkin J, Gilbert JH. 1986	Altitude. No statistical differences in incidence of symptoms or venous gas bubbles between men and women. Combined studies = 67 exposures (34 male 33 female)
Zwingleberg KM, Knight MA, Biles JB. 1987	Diving. No difference in incidence of DCS between men and women. 487 males 28 females. Differences in dive profiles between the genders and weaknesses with statistics.

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The Literature – Gender Comparisons	Conclusions
Dixon GA, Krutz RW, Fischer MS. 1988	Altitude. Women exposed to high altitude did not produce detectable circulating bubbles as frequently as men. Women experienced more symptoms of DCS than men. 30 women.
Fife W. 1989	Diving. No difference between men and women in incidence of DCS. 359 divers. These data were from an ongoing study.
Wein RW, Baumgartner N. 1990	Altitude. Concluded greater risk of DCS in women compared with men. 334 males 95 females
Eckenhoff RG, Olstad CS. 1990	Diving (in chamber). No difference in bubble formation between men and women. 54 males 30 women
Fife CE, Pollard GW, Mebane GY, et al. 1991	Diving. No difference between men and women in incidence of DCS. INA Prospective data 49 males 13 females.
St Leger Dowse M, Bryson P, Gunby A, et al. 2002	Diving. Initial analysis suggested women had higher risk of DCS than men. When underlying factors – years of experience – were taken into account, then women at less risk than men to DCS. 1,200 males 1,020 females

The Literature – the Menstrual Cycle and DCS	Conclusions
Bangasser S. 1978	Diving DCS. No difference in % of females with DCS between OCP and non-OCP groups. 29 retrospective cases of DCS.
Dixon GA, Krutz RW, Fischer MS. 1988	Altitude DCS. All 5/30 female subjects with hypobaric DCS were in menses or early phase of cycle.
Rudge FW. 1990	Altitude DCS. Significant inverse linear correlation between number of days since start of LMP and DCS incident, highest risk at the beginning of a 28 day cycle. 81 retrospective records studied.
Dunford RG, Hampson NB. 1992	Hyperbaric chamber dives DCS. Menses was a significant risk factor for inside chamber attendants, but not for divers in open water. This study was based on small numbers, 9 in total.
Schirmer JU, Workman WT. 1992	Altitude DCS. Women completing altitude chamber training without developing DCS appear to be evenly distributed across their menstrual cycle, with use of OCP not affecting their susceptibility to DCS. 508 responses.
Doyle K, Baek PS, De Long ER, Uguccioni DM, De La Dear G, Stolp BW, Dovenbarger JA, Moon RE. 1997	Diving DCS. Retrospective DAN data from 1989-95. Suggested women on the OCP were significantly more likely to experience DCS if diving whilst menstruating. Findings should be treated with caution due to the format of the questionnaire.

The Literature – the Menstrual Cycle and DCS	Conclusions
Krause KM, Pilmanis AA, Webb JT. 1998	Altitude DCS. Correlation between menstrual day and DCS: greatest probability being on day two of bleed. 62 retrospective DCS records.
Lee VM, St Leger Dowse M, Bunting AJ, Edge CJ. 1998	Diving DCS. 35% of women with symptoms diagnosed as DCS by physician were in first 5 days of menstrual cycle. 73 retrospective records.
Lee V, St Leger Dowse M, Edge C, Gunby A, Bryson P. 2003	Diving DCS. Suggested the risk of DCS may be dependent on the phase of the menstrual cycle with greatest risk of DCS, in the non-OCP group, being in the 1st week of a 28 day cycle, the lowest risk being in week 3. 150 prospective records.
Webb T, Kannan N, Pilmanis A. 2003	Altitude DCS gender related risk. Data from the non-ocp women agreed with Dunford, Krause, Lee, & Rudge, showing a reduction in susceptibility from week one through week four of the menstrual cycle. 70 women, 269 altitude exposures.
St Leger Dowse M, Gunby A, Moncad R, Fife C, Morsman J, Bryson P. 2006	Diving. Problems reported during diving were not evenly distributed over a menstrual cycle and suggested a risk factor associated with menses and diving. The highest was risk in week one, with the lowest risk in week three before rising again at the end of a 28 day cycle. 570 women, >50,000 dives, >11,000 menstrual cycles.
St Leger Dowse M, Lee V, Shaw S, Smerdon G, Fife C, Bryson P. 2006	Diving DCS. Suggested the risk of DCS may be dependent on the phase of the menstrual cycle with greatest risk of DCS, in the non-OCP group, being in the 1st week of a 28 day cycle, the lowest risk being in week 3. OCP findings less clear. 250 prospective records.

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The literature – Pregnancy the Human Studies	Conclusions
Bangasser S. 1978	Retrospective study. Found no abnormalities but cautioned against diving whilst pregnant. 72 females
Bolton M. 1980	Retrospective study. Found more foetal abnormalities (5.5%) in the diving group compared with the non-diving group (0.0%), though not significantly so. The percentage reported by the diving group was within the expected range for the national USA population at the time. 136 females reported 145 dived pregnancies.
Betts J. 1985	Retrospective study. Observed an incidence of foetal abnormalities which prompted the 20m debate in the late 80's. Results of this study may have been influenced by the questionnaire/study design. 76 females.
Bakkevig MK, Bolstad G, Holmberg G, et al. 1989	Retrospective study. Cautioned against diving whilst pregnant. 34 dived pregnancies.
St Leger Dowse M, Gunby A, Moncad R, et al. 2006	Retrospective study. Did not concentrate on foetal abnormalities specifically but looked at diving habits during pregnancy and problems during pregnancy and with the outcome. Cautioned against diving during pregnancy due to our lack of knowledge of the subject. 129 females reported 157 dived pregnancies from 1465 dives.

In all the human studies the women did not do enough dives per pregnancy for meaningful statistical conclusions to be drawn.

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The literature – Pregnancy The Animal Studies	Conclusions
Boycott A, Damant G, Haldane J. et al 1908	Pregnant goats with decompression sickness, and guinea pigs. Boycott and Haldane's seminal paper "the prevention of compressed air illness". Bubbles were seen in maternal blood in all exposures; the majority of foetuses and amniotic fluid were free of bubbles but not all. Boycott concluded the foetus was probably at no more risk than the mother.
McIver RE. 1968	Pregnant dogs. Foetus more bends resistant than mother. 28 Dogs
Fife W, Simmang C, Kitzman J. 1978	Pregnant sheep. The more developed foetus was more at risk than the mother in no-deco dives. 7 sheep
Stock MK, Lamphier EH, Anderson DF, et al. 1980	Pregnant sheep. In operated foetuses the results confirmed those of Fife; and non-operated foetuses were at no more risk than the mother. 8 sheep, 11 foetuses
Bolton ME, Alamo AL. 1980	Pregnant rats. Concluded that exposing rats to air at increased atmospheric pressure did not affect foetal health. 90 rats
Nemiroff MJ, Willson JR, Kirschbaum TH. 1981	Pregnant sheep. Bubbles detected in 8/12 ewes, but none in the foetuses.
Lehner CE, Rynning C, Bolton ME, Lanphier EH, 1982	Pregnant sheep. All lambs delivered after maternal DCS were stillborn. 12 sheep.

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The literature – Pregnancy Animal Studies	Conclusions
Gilman SC, Greene KM, Bradley ME, et al. 1982	Golden hamsters. Foetal abnormalities found in all (n=3) where mother had suffered and survived DCS. 32 experimental, 28 controls
Bolton-Klug ME, Lehner CE, Lanphier EH, et al. 1983	Pregnant sheep. Concluded that a series of short marginally tolerated dives by pregnant sheep during peak development did not affect foetal health or survival. 28 sheep
Gilman SC, Bradley ME, Greene KM, et al 1983	Golden hamsters. A high incidence of abnormalities found in foetuses from females who suffered and survived DCS without treatment. 77 hamsters
Willson JR, Blessed WB, Blackburn PJ. 1983	Pregnant sheep. Under the conditions of the study staged decompression after repeated hyperbaric exposures protected the foetuses from the destructive effects of rapid decompression. 12 sheep
Powell MR, Smith MT. 1985	Pregnant sheep and goats. Bubbles found in foetal circulation even when mother did not display signs of DCS. 2 goats, 2 sheep, 20 dives

Animal studies are controversial and contradictory in their results and may not be applicable to the human model

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