(In the presence of the jury)

MR JUSTICE GOSS: I apologise, members of the jury, for the fact that you're an hour late coming into court. There were good reasons that we couldn't proceed at 10.30, not the fault of anyone, just a combination of circumstances. We're now going to proceed with the evidence and Mr Johnson is going to call the next witness.

MR JOHNSON: Thank you, my Lord. Owen Arthurs, please.

DR OWEN ARTHURS (sworn)

Examination-in-chief by MR JOHNSON

MR JOHNSON: Would you start by identifying yourself, please?

A. I'm Owen John Arthurs.

Q. And your profession, please?

A. I'm a consultant paediatric radiologist at Great Ormond Street Hospital in London.

Q. A paediatric radiologist. What does a paediatric radiologist do, please?

A. A radiologist is a specialist in images and image interpretation and my special interest is in doing that in children.

Q. Thank you. And your qualifications, please?

A. I'm a fellow of the Royal College of Radiologists, I'm a fellow of the Royal College of Paediatrics and Child Health, and I hold a PhD in imaging, and I am now professor of radiology at Great Ormond Street Hospital.

Q. Thank you. You have reviewed many of the children in this case, haven't you?

A. I have.

Q. The two that I'm going to ask you about today are [Babies A & B]. And you have written several reports on each; is that right?

A. Yes, I have.

Q. Just as a little bit of background, can we start with [Baby A] first. I think you were given information about [Baby A]'s birth, his weight at birth, his gestation at birth and also details of when he died?

A. Yes, that's right.

Q. And I won't ask you to repeat those because the jury has already heard that information. But what in general terms were you invited or instructed to do?

A. So I was to review the imaging of [Baby A]. He had several X-rays taken when he was alive. He also had several X-rays taken after he died, which were done in Alder Hey.

Q. And Alder Hey is the children's hospital in Liverpool, isn't it?

A. That's right.

Q. Thank you. From time to time some of the witnesses in

this case use the phrase "radiograph"; is that the same as an X-ray or is it different?

A. Technically, the X-ray is the beam that passes through the body to produce the image, so the image is technically a radiograph, but the popular term for the images has become "X-ray images", so use of the term X-rays is fine.

Q. Thank you. Can we deal first, if we may, with material other than the images that you've seen. Were you sent reports from other medical practitioners?

A. Yes, I have, and I think I've detailed those in my reports.

Q. Yes. They included, I think, three reports from Dr Dewi Evans?

A. Yes.

Q. And a report from Dr Andreas Marnerides?

A. Yes, that's right.

Q. Dealing with the in-life X-rays first then if we may, if we could just put these on the screen to remind the jury. They are tiles 31, 128 -- I'm not going to go to these individually -- thank you. This is just for the jury's benefit if they want the information at the moment. 128 is the next tile. 142. And finally, 156.

Can we just go to that image, please, the one at 156?

Dr Arthurs, is it right to say that, broadly

speaking, those four images are similar?

A. Yes, that's right.

Q. And they're all slightly different because they're taken at different times of a child from not in exactly the same position. Is there anything unusual about any of the four images?

A. In [Baby A], no, there's nothing particularly remarkable about the images that we have in terms of his heart and lungs. I think the only comment that I made was about the umbilical catheter that was in slightly the wrong place.

Q. Yes. We've heard some of the treating doctors talk about that. So nothing remarkable about those images. Just so that the jury have this as a reference -- and this is the first time we've actually looked at any of the X-rays, really -- we can see at the bottom right-hand edge of the picture, there is a date and timestamp. Is that stamped by the machine?

A. It's either stamped by the machine or by the radiographer when they acquire the X-ray, so it's a date of acquisition to document exactly when it was done.

Q. Yes, and in this context does acquisition mean taking the picture?

A. Yes, that's right, apologies.

Q. Top left-hand corner, name, sex, presumably an individualised identification number for the child

concerned?

A. Hospital number, so that will be Countess of Chester, and then a six, seven or eight-digit number.

Q. Is there any significance in any of the other --

A. No, they show the parameters that have been used by the machine to take the image.

Q. Right. When you -- well, you were also shown or given seven images of [Baby A] that had been taken after his death?

A. That's right, yes.

Q. Those images were taken, as you've told us, as Alder Hey?

A. Yes.

Q. And taken on 11 June?

A. I think they were taken on the 10th, actually.

Q. I beg your pardon.

A. There's an error in some of the documentation, but yes, that's right.

Q. I'd just like to show you one of those images, please. Just to orientate -- well, could you orientate us, please, as to what we're seeing here?

A. Do the jury have the image that I can see here --

Q. Yes.

A. -- in the quality that I can see it? Because I think the quality of what's been projected is not as good. Can you all see it on the screens in front of you?

This is image taken laterally through the baby with the baby lying down. The head is on the left-hand side of the image and the pelvis -- you can see the two femurs on the right-hand side of the image as you are looking at it. The bones of the spine are shown all the way in sequence along the bottom. And in fact, just beneath the skull, you can see some of the tubes and those are the things that were still in place. So there's an endotracheal tube, for example, crossing the neck.

Q. Is that at the top of the neck?

A. The top, yes. There are two lines and there's a nasogastric tube as well just below that.

So X-rays show bones as white because they prevent the X-rays from going through them and they show gas and air, for example, as black.

Q. Just for the purposes of general education, really, because these issues become relevant at a later stage although they're not relevant to this particular case. What can we see just to the left of where the femurs start, that sort of dark area there?

A. If you move your cursor up, this is gas within the bowel, a normal feature of post-mortem radiographs. The block of gas that is the black area which is to the left of that, further up in the body, is gas within the heart.

Q. Yes. Below the heart that we can see there, is that the nasogastric tube which is running --

A. That's right, that's the white tube that ends just there (indicating). So that would be presumably in the stomach.

Q. Yes. Is there anything that's unusual about this radiograph --

A. Yes. The comment I made about this radiograph is that you can also see, as well as all the normal expected gas that you would see in a baby in a post-mortem state, you can also see a line of gas just in front of the spine. So that runs almost from there (indicating) almost all the way up to there (indicating), that's right.

Q. Okay. Would you normally expect to see that?

A. No. That's an unusual finding.

Q. So far as how it comes to be there, what are the possibilities from your perspective?

A. So that finding is so unusual that I reviewed several of my existing cases in the series of radiographs that we have at Great Ormond Street to try and identify in what circumstances that might occur. In my report I've gone in length into the possible circumstances in which we often see that type of gas.

So firstly, it's quite unusual. So in several hundred radiographs of babies who have died of natural causes, we don't see gas in that location.

Q. Right. Let's just take this slowly, if we may, please. A death from natural causes, you just don't see that?

A. We don't see that. That's right.

Q. And so far as unnatural causes are concerned, what are the possibilities?

A. So if there's been a severe fracture somewhere in the body then gas could be introduced and then circulated and it could be seen there.

Q. Right. Now, this is your day-to-day experience, we're all novices. How does a fracture introduce air into the body in a position like this?

A. I don't mean a fracture of a bone, a simple bone, something like that. Something like a road traffic accident, if you were to have a fracture through your skull base, it might also break the blood vessels and then air can track into the blood vessels. So what I'm talking about is severe road traffic accidents, those kind of things.

Q. Okay. So we know this child was in hospital from birth to death, so we can exclude road traffic accidents?

A. Yes.

Q. What's the next possibility?

A. The other circumstance in which we've seen it has been overwhelming infection, sepsis.

Q. Yes. Sepsis is a term that most jurors will have heard. It may be that some of them, like me, don't really

understand what it means. What is sepsis?

A. Sepsis is essentially overwhelming infection in most of the organs of the body.

Q. If it was a case of sepsis, would you see evidence on the radiograph, on the X-ray, of problems with the organs as well?

A. So, no, not always because, as you can see, what we mainly see on X-rays are bones and gas, and we can't distinguish very much else of the other soft tissues.

Q. Okay. So in order to determine whether or not sepsis was a possibility in this case, what would the jury have to look at in terms of other evidence in the case?

A. This baby died, so there would have been an autopsy, and there would be clear identifiers from a pathology point of view as to whether or not the baby had overwhelming infection.

Q. Right. On the basis that we exclude that as a possibility, what's the next possibility?

A. We have seen it occasionally, and very occasionally, in babies who have died outside of hospital. So the term for unexplained death outside of hospital in infancy is S-U-D-I, SUDI, or sudden unexplained death in infancy.

Q. Why do you put the restriction on babies who die outside hospital rather than including those who die in hospital in this context?

A. SUDI is effectively a diagnosis of exclusion when all

other things have been excluded in an otherwise well baby who wasn't being treated for anything, who went home, was feeding normally, et cetera, et cetera, and then unexpectedly collapsed at home. It is a recognised phenomenon that occurs in babies in the age of about 3 to 9 months. Again, a pathologist would be able to tell you much more about SUDI as a concept than I will.

Q. But this case plainly, for the reasons you've given us, doesn't fall into that category?

A. That's right.

Q. So what is the next possibility, please, Dr Arthurs?

A. We have seen it in some children who have undergone extensive resuscitation. I am just referring to my report, where we didn't see this very commonly on radiographs in that circumstance, but we are now performing CT scans, which are more detailed scans, of babies who have had died, which allows us to see smaller locules of gas and smaller and smaller -- better imaging, effectively.

Q. So a CT scan is more discriminating?

A. Yes.

Q. Okay. Sorry, I interrupted you.

A. No, no. In that sense we have seen it occasionally following resuscitation and the premise is that -- we hypothesise that there is some natural gas in the body after death and it is possible therefore the

resuscitation could circulate it around if it were successful in moving blood around with gas in it.

Q. Are there any other possibilities as to how this gas got there?

A. So if you end at that point, effectively this is unexplained.

Q. Yes.

A. We do know that the baby had an umbilical venous catheter in situ and we do know that gas can be introduced into vessels through catheters and devices that medical people have put there.

Q. Yes.

A. So through cannulas, through long lines, through umbilical catheters, you can introduce gas.

Q. We know as a matter of evidence that there was also a long line in this child.

A. Yes.

Q. It had been removed by the time these images were taken.

A. Yes. The umbilical venous catheter actually is still in.

Q. Yes, but the long line had been removed?

A. Yes.

Q. Can gas -- is it possible that the gas was introduced via one or other of those lines?

A. Yes, it's possible.

Q. Is the appearance of the gas that we see in the image on

the screen consistent with that as a method of introduction?

A. Yes. So the sensible, most pragmatic conclusion to bring would be that in the absence of any other explanation, that would be an alternative explanation.

Q. But lest we read too much into it in isolation, is what we see in the image diagnostic of, ie does it say, yes, that is definitely how this gas was introduced?

A. No, it doesn't. All the image shows you is gas in one of the large vessels of the body on a post-mortem radiograph of a small baby.

Q. Have you ever seen this much gas in a child's body that hasn't been explained?

A. Only in one other case, which I think we'll discuss later on.

Q. This is one of the other children in this case?

A. That's right.

Q. So far as your opinion was concerned relating to this radiological finding in the body of [Baby A], what was your final opinion, please, doctor?

A. So my opinion was that this was an unusual appearance. This is not typical of any of the radiographs we normally see in this circumstance, and in the absence of any other explanation, this appearance is consistent with but not diagnostic of air being administered.

Q. What some might call an air embolus?

A. Yes. I'm not sure I would say this is evidence of an air embolus, but I think this would be consistent with air having been administered.

Q. Yes. All right. Just so that the jury understand why my use of language is incorrect, could you explain why air embolus isn't the correct label to put on what you can see in the image?

A. To me an air embolus is effectively a cause of death, so sufficient air having been entered into the body and which kills the patient. I am not sure you can say that that's what's happened from this image.

Q. And you're looking at it from your --

A. Purely from a radiological perspective.

Q. So you're not taking into account any of the other evidence at all in the case?

A. That's right.

Q. You're looking at the image and saying what you can see with your expertise from that image?

A. Yes.

Q. Thank you. Can we turn to the case of [Baby B], please, [Baby A]'s sister?

Again, Dr Arthurs, were you approached to consider the evidence in the case of [Baby B]?

A. Yes, that's right, I was.

Q. And did you review a number of images in her case?

A. I did.

Q. Were they dated -- I'm not going to run through them as I did with the other case. Were they dated the 8th and 10 June?

A. 2015, that's right.

Q. Thank you. And taken at various times on those dates. Is there anything that you saw in any of the images of [Baby B] that were unusual?

A. No. In my report I've gone through six radiographs. [Baby B] was 31 weeks, so premature. [Baby B] shows some changes in lungs, which are that of premature lung disease, which would be expected, and there are no real other abnormalities to comment upon from a radiological perspective.

Q. Does the lack of abnormalities from a radiological perspective inform the issue of whether or not anyone injected air into [Baby B]?

A. I think we need to consider that separately to [Baby B]'s images.

Q. Yes.

A. So if we consider an air embolus as a concept, in my experience we very rarely see air embolus as a cause of death or as a radiological diagnosis.

Q. Why is that?

A. There are several reasons. One is that very, very small amounts of air probably enter the body quite often when we give injections or those sort of things. We never

take images of those, they never cause any problems, they disappear on their own and they -- so clinically, the baby and the child is asymptomatic.

Q. Yes.

A. An air embolus to the point where it causes clinical symptoms is usually so massive that the last thing someone is rushing to do is to do an X-ray. So they would be so busy trying to resuscitate the child at all costs that very rarely is there an X-ray at the same time to demonstrate that that was what happened.

Q. So in the context of the jury having the issue to decide as to whether or not there was an air embolus in [Baby B]'s case, does the image help either for or against that as a proposition?

A. No. It doesn't help for or against. So the absence of air doesn't mean that that didn't happen and then the air has disappeared. The presence of air would help obviously make that -- but you can understand why that very rarely, rarely occurs.

MR JOHNSON: Would you remain there, please, Dr Arthurs? It may be that there are some further questions for you.

Cross-examination by MR MYERS

MR MYERS: I just have some general questions to ask you about air in the body and your analysis of that, Dr Arthurs.

A. Yes.

Q. And then I'll look at the two cases that we've looked at here, but there may not be a great deal extra that I need to ask you about them. Just to confirm some general points, radiographic evidence of air embolus is rare, isn't it?

A. Yes.

Q. What you're able to tell us is that where you do encounter air in the system, particularly I am talking about in images taken during life, that is caused by medical procedures or the placement of lines into the patient's body?

A. Yes. That's usually the scenario.

Q. And indeed, on post-mortem imaging, that's another regular explanation for how it is that air could be present?

A. Could you rephrase that?

Q. Well, on post-mortem imaging, the presence of air may also be the result of medical procedures or placement?

A. Yes, that's reasonable.

Q. I'll leave the question of how often out of it for the time being.

A. Okay.

Q. We may hear more about this later, but just so the jury can keep up with where we are in talking about this, Dr Arthurs, when we talk about air entering the body because of the placement of vascular lines, that refers

to the potential for something like a UVC, that we've heard about, or a long line being open to the air for long enough for air to pass through that and into the patient's body?

A. Yes.

Q. And that's something that can happen in practice?

A. Yes. That's right.

Q. Would you agree that it is rare to identify air embolus from radiographic imaging?

A. Yes.

Q. I'm going to ask you a few questions about air in the body in life and then about the post-mortem situation.

If we want to be able to identify and accurately diagnose air embolism in images in life, you would require imaging that showed the presence of air in blood vessels where there is no other explanation for the air being there?

A. Um... You...

Q. Apart from -- no other explanation apart from being introduced externally.

A. Yes. I think that you would -- in order to... So in order to see air on images in life, you would seek an explanation as to how they got there, one of which could be that they had entered the body through medical administration. Is that the question you were asking?

Q. Well, what I'm asking really is this, that the gold

standard of identifying air embolus would be, first of all, an image showing the presence of air in the body in life?

A. So that I disagree with. That isn't the gold standard. As we have said --

Q. What is the gold standard, let me ask?

A. It would be a clinical diagnosis as the most likely cause or potentially it would be identifiable at post-mortem. I think the assumption that an image is needed to prove that air embolus occurred is wrong for precisely the reasons that we've given.

Q. Because you have to look at it in the context of the history and all clinical findings?

A. Yes.

Q. That's what I was going to ask. So what you have to do is look at the imaging and then you or you and others will look at the imaging together with the surrounding circumstances?

A. Yes, that's right.

Q. So far as imaging post-mortem, so after death, is concerned, you've explained to us that doing the research or the studies you've done, you wouldn't normally expect to find gas in the vessel or the vessels that we see on the image we've looked at?

A. That's right.

Q. Right. Would you say that in general, the significance

of gas in the large vessels on post-mortem radiographs is not known?

A. I would say that when we see it, we usually have an explanation for it in the examples that I have given already.

Q. Post-mortem gas in the body is a natural phenomenon, isn't it?

A. Yes, that's correct.

Q. So you may well expect to find, in your work, gas in various parts of the body after death?

A. Yes.

Q. And the build-up of gas after death can commence quite quickly, can't it?

A. Yes.

Q. (Overspeaking) to start?

A. I don't think anybody knows how quickly but, yes, it can and seeing gas on images in normal vessels on post-mortem radiographs is common, yes.

Q. Is it the case that the more time passes, the greater the quantity of air -- the greater the quantity of gas?

A. I think that's logical but I'm not sure that's necessarily proven.

Q. When you give us the conclusion or the opinion that the gas in the vessels is an unusual finding, where you've said that, is that something that's based on your own research from your own cases in your clinical work?

A. Yes, and it's based on published literature that that's not a common phenomenon, yes.

Q. In your reports you set out in some detail why it is that you say that, don't you?

A. Yes.

Q. Can I just explore that with you so we understand what you mean by that.

A. Yes, of course.

Q. The review of cases that you have undertaken took you to a conclusion that you might expect to find that gas in 25% or fewer cases; is that correct?

A. My Lord, perhaps I should explain the reason why I went and did that review of the cases that I set out in my report.

Q. I'm going to -- with his Lordship's leave I am going to take you through that, but I leave it to you to answer it how you wish.

MR JUSTICE GOSS: Right.

A. So when first we saw the gas in those locations, for me to be able to say that it is unusual, I had to go back and review cases because we know that gas is common in the heart, in some of the other locations, so I posed it to myself: perhaps we actually do see this commonly and we haven't appreciated it previously. So the reason to go back and investigate all of the children that we have is to see whether I could actually make the statement

"this is unusual" with any degree of confidence. And there are three studies that I went through, one of which is published, based on CT, of children who have died and then more extensively going back through several babies who have died in our unit in a teaching case that we have and the conclusion from that is that it is indeed unusual.

MR MYERS: And you give a figure in your report -- I'm looking at page 499, so this is the report dated 19 May 2020, it's page 8 of that report -- at page 10 of that report.

A. Yes. So the figures I came up with in looking back through different groups was that approximately a quarter of the babies that we looked at had gas in the large vessels.

Q. Right. So when you say you give us the figure that -- it's an unusual finding to find gas there in terms of your research, that translates to 25% of the cases which you have gone through, that's what you found?

A. That's right.

Q. Right. I'm not going to question you about whether 25% is unusual or not, but that's the way you characterise 25%?

A. 25% of the children that we came across, the majority of whom had an explanation.

Q. As to how you get to that, I just want to ask this.

You'll be familiar, Dr Arthurs, with evidence-based medicine, won't you, that approach?

A. Yes, that's right.

Q. For those of us who aren't so familiar, that means basing an opinion on sound research; that's right, isn't it?

A. Yes.

Q. Recognising deficiencies in it and recognising where we simply don't know?

A. That's right.

Q. When we come to look at the cases upon which you base your conclusion, there's a published paper you looked at, written by Barber and others, isn't there?

A. That's a paper on which I was a senior author, yes.

Q. In that case, and I'm going to go through this so we can follow why we get to you saying unusual, in that case -- and you refer to this at page 10 of your report -- you found 60% of the children had gas in some location of their body after death.

A. Yes, that's right.

Q. So that's where you started on the report you worked on. But when you looked at that, you saw that dealt with children whose average age was 2 years, didn't you?

A. Yes. These are older children and that study used CT.

Q. So you then turned from that work to records at your own hospital, didn't you?

A. That's right.

Q. If we're going to have research and an evaluation of how often something comes before you in your work, the best research will be designed specifically to investigate an issue, won't it, it's prospective?

A. Yes.

Q. So it will define what it's looking into, won't it?

A. Are you arguing that we should have done a study --

Q. I just want to go through what you did do.

A. Okay.

Q. It will control variables, things that can change?

A. Yes.

Q. It will be conducted objectively, by which I mean, for example, the person reviewing the X-rays in that research may be masked from other clinical information?

A. Yes.

Q. When you came to do your research, you had already -- I'm not being critical of you for this, it's inevitable, but you'd already been provided with an outline of what the investigation was about, hadn't you?

A. For the purposes of this I'd been provided with a hypothesis.

Q. A hypothesis, yes. If you're engaging in specific research you would try to have as wide a pool of subjects to base your research on as possible?

A. Yes, which are representative of the question in hand.

Q. And then the research would be what's called peer reviewed?

A. Yes.

Q. Which means that other specialists can look at it critically and assess it?

A. Yes.

Q. In coming to the finding that this is unusual, and the figure of 25%, what you did was to begin by narrowing down 500 cases that you had at Great Ormond Street, didn't you?

A. Yes.

Q. Of those 500, a very large number of them were foetuses or stillborn, weren't they?

A. Yes. That's correct.

Q. I just pause there to say, the hospital where you work is Great Ormond Street, isn't it, Dr Arthurs?

A. Yes, it is.

Q. You then narrowed down from those 500 to children who are under the age of 1 when they died; is that correct?

A. Yes, that's right.

Q. Just pausing there, I'm going to carry on. Neonates are a specific group of babies, aren't they, as in 1 to 4 weeks as a rule?

A. Yes, that's right.

Q. And one cannot simply take studies of older babies or children as being indicative of what happens with

a neonate in the period of 1 to 4 weeks?

A. No, but that wasn't the purpose of what I was doing here.

Q. No, you were looking to see the occurrence of gas in those vessels?

A. Yes.

Q. Yes. Of the 100 who were under the age of 1 when they died, you narrowed that down then to 38 children who were under 2 months of age at the time of death?

A. So we're now moving on from the 500 cases where I went through to look at their X-rays --

Q. Yes.

A. -- and I found six cases in slightly older children where gas was identifiable on the large vessels.

Q. Yes.

A. And of those, five had had traumatic injuries and the sixth child had died of sepsis. So in fact there was an explanation for the gas in the great vessels on all of those children from my radiographic study or the investigation that I did of their cases that I had. However, I then went into detail into the CT scans that we have on children under the age of 1, and I found 100 cases of those, of which 38 were babies under 2 months of age. So of those I found eight cases where they had gas in the great vessels and they had died of trauma, road traffic accidents, sudden unexpected death in

infancy, congenital heart disease, and disseminated malignancy. So we had found no unexplained cases of gas in that location after a detailed review.

Q. Your findings though are based, let's get this clear, on the basis of eight out of 38 babies; yes?

A. So my findings are based on the case review that we have, which is probably the largest available.

Q. The review you did comes down to narrowing it down to 38 babies who were under 2 months, that's where you get to?

A. Yes.

Q. It can't be said from the information you have that that's representative of babies who are 1, 2 or 3 days old?

A. No, it's representative of the typical deaths that we encounter that are referred to Great Ormond Street Hospital.

Q. Which itself is a particular class of work, isn't it?

A. Yes.

Q. It's not necessarily representative of every neonatal unit in the country, is it?

A. It's representative of perinatal autopsy in the types of babies who need a cause of death established.

Q. But the figures you're giving us, to be clear, are not based upon neonates in the first few days of life who are preterm exclusively, are they?

A. The vast majority of those don't die.

Q. But the figures we have -- did your study group focus upon neonates 1 to 3 days old or a week old who were preterm?

A. I can't tell you exactly from there, but they will have been included in the study if they died at my hospital.

Q. You can't tell us though?

A. No.

Q. You can't tell us how much time, can you, passed from death to imaging in the cases that you're relying upon, can you?

A. No, that's right.

Q. And you can't tell us, for instance, things like the specific temperatures in which, sadly, the bodies were kept before imaging was taken?

A. The 4 degrees is the standard temperature that they're kept in the mortuary refrigerator.

Q. And the particular circumstances of death that we are dealing with in this case are not replicated, I'm talking the clinical circumstances, are not replicated in your work, are they?

A. How do you mean they're not replicated?

Q. You were unable to identify from the children you looked at, Dr Arthurs, any that died in circumstances clinically that are the same or similar to the ones we're dealing with in this case, the circumstances of death?

A. No. In the sense that the circumstances of death of these children are quite unusual, it would be reasonable that none of them were represented in the sample that I looked at.

Q. The point I'm making, I hope clearly and respectfully, is there are many variables that can apply to a study when research is conducted upon it, aren't there?

A. Yes.

Q. And what you rely upon in telling us that you wouldn't normally expect to find gas in the vessels post-mortem is in effect, and I don't say this disrespectfully, but an informal review of cases from your own institution, isn't it?

A. Yes, it's what you would call an observational study or clinical experience.

Q. But it's not a controlled study, is it?

A. I'm trying to imagine how you would do a controlled study.

Q. Well, I'm not asking you to imagine how. The proper approach would be to have a controlled study, if at all possible, wouldn't it?

A. And what would a controlled study look like? What are the variables that we're trying to control in this particular circumstance?

Q. I'm not the claiming to be the expert, Dr Arthurs, I am asking you to confirm that this isn't a study with any

set controls on it. It's made out of what you could find out of records looking through what you had at Great Ormond Street, isn't it?

A. Yes, that's what an observational study is.

Q. Again not disrespectfully, but it lacks objectivity and independence in that it is conducted by you looking into a theory that you've been asked to consider?

A. No, it lacks objectivity in the sense that it's an observational study of what data was available at the time. I'm trying to understand -- I think your question is directed at this, that an alternative study could have been done and that is why this study is insufficient?

Q. No, I'm looking at ways in which this may come below a higher standard of evidence-based medical research.

A. Oh, I see.

Q. That's why I began by asking that.

A. So observational studies and clinical experience are not the highest levels of evidence-based medicine. However, sometimes they are the only evidence that we have on which some conclusions can be drawn.

Q. And do you agree that --

MR JUSTICE GOSS: Just let him finish. Are you finished?

A. That's what I have tried to provide to the court to try and contextualise how commonly this occurs, some potential explanations for it, and with the

deficiencies, as you have kindly pointed out, in doing so, that is the basis on which I can provide my evidence here today.

MR MYERS: So it's quite clear, and it's not meant to be discourteous or difficult in any way, but if we are expected to rely upon what you tell us, I'm anxious that we explain to the jury the circumstances in which you come to that assessment.

A. Yes, it's entirely reasonable.

Q. Yes. The study that you conducted, based on material from your own institution, has not -- again this isn't to be rude -- been peer-reviewed or validated by anyone beyond what you're telling us now?

A. No, that's correct.

Q. And it may well be that you have no alternative but to work with the numbers of babies you work with, but we come down to what you find in the case of eight babies out 38, don't we?

A. That is my clinical experience.

Q. Yes. I'm not being critical of that and I'm not saying it's easy to do, but when we hear the finding that it is not what you'd normally expect or it's unusual, that is what that finding is based upon?

A. That's right.

Q. And I think the figure which that works out at, as a simple bit of maths, is in 25% of those cases there

was gas in the great vessels post-mortem?

A. Yes, that's right, the majority of which had an explanation.

Q. Yes. Moving on to other ways in which we might find air in the system. We've dealt with air entering the system because of medical procedures or the medical profession. You accept, do you, Dr Arthurs, that air may enter the system as a result of CPR, the resuscitation?

A. I don't think air enters the system as a result of --

Q. Is liberated within the system as a result --

A. -- but can be distributed.

Q. It can be distributed. And so if there has been resuscitation that has taken place, independently of the 25% point, that may be what's called a differential diagnosis? That's an alternative explanation for the air that we find.

A. Yes, it's an alternative explanation, that's right.

Q. Where [Baby A] is concerned, there are a number of potential explanations for the air that we see in the X-ray that we looked at, is that right, Dr Arthurs?

A. There are a number of potential explanations, that's right, yes.

Q. And subject to all the circumstances, they can be assessed, but the potential explanations that you provide us with is air being introduced from outside, what was called at one point air embolus, if I recall.

A. Yes.

Q. You make the point, well, air embolus presupposes that someone's -- the way you put it, it presupposes a cause of death, how it was done.

A. Yes.

Q. From the radiographs, you can't say that; that's right, isn't it?

A. Yes, that's right.

Q. But you can say one possibility is air coming in from outside?

A. Yes.

Q. Another possibility is post-mortem changes?

A. Yes.

Q. Which is what we're looking at with the 25% figure and the research.

A. (Witness nods).

Q. Another explanation is resuscitation, potentially?

A. Yes.

Q. What you can say, concluding all of that, is that, therefore, air being present where it was found is consistent with an air embolus, but it isn't diagnostic of it?

A. Yes, that's right.

Q. And it could be consistent with the other explanations we've looked at as well, depending upon the overall circumstances?

A. Yes.

Q. In the case of [Baby B], what you identified, Dr Arthurs, from the chest radiographs you saw, suggests in addition to your conclusion you identified radiographs showing "mild lung disease of prematurity and its complications"?

A. That's right.

Q. The radiograph -- one radiograph you saw is dated 10 June 2015, taken at 01.09?

A. Yes, that's right.

Q. The jury will know from evidence, and you may or may not know, that the collapse takes place round about 00.30.

A. (Witness nods).

Q. So that means that radiograph is taken about 40 minutes after the time of collapse?

A. Yes.

Q. And on that radiograph, there are no radiographic features to support air embolus, are there?

A. Yes, that radiograph doesn't show a significant abnormality.

MR MYERS: Thank you, Dr Arthurs.

Re-examination by MR JOHNSON

MR JOHNSON: Just dealing with that last point, Dr Arthurs, the absence of a significant abnormality. What can we read into that either way, given the time frame that's just been explained to you?

A. I can only speak to the radiographs, but I don't think you can conclude anything either way.

Q. No. Thank you.

It may be that I misunderstood the questioning, but it appeared that one of the criticisms of your reviews of other cases was that in effect you were comparing apples with oranges, putting it in layman's terms. Would it have been possible to do your exercise any other way than how you did it? In other words, look at other cases and try and contextualise them to the facts of this case?

A. I think it's very difficult to come up with hypothetical ways in which something can have occurred. What I have tried to do is present what is quite a large body of evidence of how children and babies normally die and the circumstances and what we see on the imaging. So by looking back through all of my cases and showing that this is not a common finding in the absence of another explanation, that's probably the best observational study that we have currently to say that this is an unusual finding.

Q. Yes. And when you say this is an unusual finding, are you referring to that line of gas that we see --

A. That's right, yes.

Q. -- above the spine of [Baby A] in the radiograph?

A. That's right, yes.

MR JOHNSON: Thank you.

Does your Lordship have any questions?

Questions from THE JUDGE

MR JUSTICE GOSS: Just this: you've been asked questions by the advocates who have read your reports and are familiar with the case. The jury haven't seen any of your reports. They don't know precisely the study to which you're referring.

First of all, when did you carry out these observational studies and clinical experience of these other cases?

A. So there's a published study in 2015 where we looked at how commonly gas occurs in older children when they die.

MR JUSTICE GOSS: And you looked at -- that's general parameter and how many cases did you consider there?

A. 35, I think we found, and we found that 10 had some gas in the large vessels. So that study is published, peer-reviewed, available in the literature.

MR JUSTICE GOSS: Yes.

A. Because that study is of children, which actually may not have included babies, you can't directly infer from that study to what might have happened in [Baby A]. Hence the review of some of the work that I've done.

MR JUSTICE GOSS: So your definition of children -- a child in law is someone under 18?

A. Yes. So anyone -- so probably 1 to 16 were probably

included in that study.

MR JUSTICE GOSS: Right. How many were of babies who were 1 or 2 days old?

A. I can't tell you off the top of my head, but very few probably in that study.

MR JUSTICE GOSS: And were premature?

A. Probably none.

MR JUSTICE GOSS: Probably none?

A. Probably none in that study.

MR JUSTICE GOSS: Is there any reason for there being so few?

A. That study was independent of the question here.

MR JUSTICE GOSS: Yes.

A. So that study was performed in order to say: when we see gas on CT in children, does it mean anything, is it related to something that they've had, is it something we can infer something from? And the conclusion of it was that we saw it after traumatic deaths and we think that resuscitation might move some of the gas around the body. That's all we can say from that study. I didn't want to present that study and then draw inferences to the cases we have in front of us today without having made some reference to the types of children that I see on a day-to-day basis.

MR JUSTICE GOSS: And the children, they can be from neonates --

A. They can.

MR JUSTICE GOSS: -- up to teenage years?

A. Absolutely. Which is why I've then gone forward to try and specifically look at children who have been born and subsequently died within the first few months of life, so typically under 1, for the purposes of trying to get sufficient number of children to try and say something about. And that's where some of the numbers in my report come from.

So in 500 babies under 1, who, if you take out all of those who were born and never breathed, for example, quite a lot of foetuses and stillbirths, we can find 46 children who had been born and subsequently died in the first few months of life and, of those, we found that six had gas in those locations, all of whom had had trauma to the body, head injuries, road traffic accidents, allowing gas to enter the body through fractures, and the sixth child had died of an overwhelming infection in sepsis. So I'm trying to contextualise from my clinical experience how common it is to see gas in this exact location on a post-mortem radiograph in a child without any history. And the conclusion I've drawn is it's unusual.

MR JUSTICE GOSS: Thank you.

Do you want to ask any questions arising out of that, Mr Myers?

MR MYERS: Nothing from that, my Lord.

MR JUSTICE GOSS: I have gone back over ground but I wanted to make sure it was clear to the jury what Professor Arthurs was saying, because obviously this is your bread and butter, your daily work.

A. Yes.

MR JUSTICE GOSS: Right. Anything you want to ask, Mr Johnson?

MR JOHNSON: No, thank you, my Lord.

MR JUSTICE GOSS: We will be seeing Professor Arthurs again?

MR JOHNSON: We will.

MR JUSTICE GOSS: But not today. Thank you very much indeed for coming. You know the rules. Don't talk to anyone about this case, the evidence, anything relating to it.

A. Yes, my Lord.

MR JUSTICE GOSS: Thank you very much indeed.

(The witness withdrew)