

# OPUS2

Manchester Arena Inquiry

Day 150

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1 Tuesday, 21 September 2021  
 2 (9.30 am)  
 3 (Delay in proceedings)  
 4 (9.40 am)  
 5 MR GREANEY: Sir, good morning. We are now going to hear  
 6 further evidence in chapter 11 and the evidence today  
 7 will be from two members of the blast wave panel of  
 8 experts. We are going to hear from  
 9 Professor Anthony Bull and Colonel Peter Mahoney, and  
 10 I will begin by asking each to be sworn.  
 11 PROFESSOR ANTHONY BULL (sworn)  
 12 COLONEL PETER MAHONEY (affirmed)  
 13 Questions from MR GREANEY  
 14 MR GREANEY: Gentlemen, do you form two of five members of  
 15 the group of five experts that we have described as the  
 16 blast wave panel?  
 17 PROFESSOR BULL: Yes, we do.  
 18 Q. Have you been provided with instructions to assist the  
 19 inquiry in relation to certain expert issues?  
 20 PROFESSOR BULL: Yes, we have.  
 21 Q. Professor, before we turn to those instructions and  
 22 moreover to your substantive evidence, it's important  
 23 that we make one thing clear to the public. Is it the  
 24 position that today you are here to provide your  
 25 overview evidence only --

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1 PROFESSOR BULL: Yes, that is.  
 2 Q. -- to help us with a series of concepts with which  
 3 we will become familiar during chapter 12?  
 4 PROFESSOR BULL: Yes.  
 5 Q. And that as a result, you will not be dealing  
 6 specifically with events at the arena?  
 7 PROFESSOR BULL: That's correct.  
 8 Q. Although it may from time to time be relevant to  
 9 understand whether particular terms and concepts are  
 10 relevant to our investigation?  
 11 PROFESSOR BULL: Yes.  
 12 Q. Is it also the position that you will therefore not be  
 13 dealing with any individual deceased?  
 14 PROFESSOR BULL: That's correct.  
 15 Q. But that you will return later in our process to deal  
 16 with events specific to the arena and with the 22 who  
 17 died?  
 18 PROFESSOR BULL: Yes.  
 19 Q. Professor, I'm going to begin by asking each of the two  
 20 of you in court about your qualifications and background  
 21 and then, professor, I'm going to ask you to introduce  
 22 us to the qualifications and background of the other  
 23 members of the panel who are not here today but who did  
 24 make a contribution to your reports and will give  
 25 evidence in due course.

2

1 Professor, first of all can I invite you to identify  
 2 yourself.  
 3 PROFESSOR BULL: I'm Anthony Bull, I am a bioengineer, I am  
 4 head of the Department of Bioengineering at Imperial  
 5 College. I also lead the Centre for Blast Injury  
 6 Studies, which is an interdisciplinary activity with  
 7 engineering, medicine and science that investigates  
 8 blast injuries from point of wounding, mitigation,  
 9 protection, and rehabilitation.  
 10 Q. Does that centre have strong links with the military?  
 11 PROFESSOR BULL: Yes. We have military medical and  
 12 personnel embedded within the centre since we started in  
 13 2008. My personal research is in the area of the effect  
 14 of forces on the human body that cause trauma, but also  
 15 in other domains such as sporting injuries and  
 16 performance. Obviously relevant today is those for  
 17 trauma, specifically blast injury.  
 18 Q. Has the centre that you've described conducted  
 19 world-leading and cutting-edge research and translation  
 20 activities in understanding blast injury from the point  
 21 of wounding?  
 22 PROFESSOR BULL: Yes, that's correct. Our expertise is  
 23 unique, there is no centre like this internationally, in  
 24 particular a centre that incorporates both medicine and  
 25 engineering, which allows us to investigate the physical

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1 effects and the medical effects and their interaction.  
 2 Q. And you've described your extensive experience of trauma  
 3 research. Is it also relevant to identify that you were  
 4 rewarded for that work with a fellowship of the Royal  
 5 Academy of Engineering in 2014?  
 6 PROFESSOR BULL: That's correct. In addition, I am a member  
 7 of the World Council of Biomechanics, where biomechanics  
 8 is the science of how mechanics, that is forces and  
 9 deformation, interact with the human body, and there are  
 10 only 40 members of that worldwide.  
 11 Q. Professor, I am going to turn from you, unless there's  
 12 anything you would like to add, to the colonel and ask  
 13 Colonel Mahoney to identify himself, please.  
 14 COLONEL MAHONEY: I'm Colonel Peter Mahoney. I was a member  
 15 of the regular army until March 2020 and now I'm  
 16 a member of the reserve forces. Professionally, I am  
 17 a medical doctor and my specialty is anaesthesia and I'm  
 18 a consultant in anaesthesia.  
 19 Q. Do you have further additional qualifications in that  
 20 area of practice?  
 21 COLONEL MAHONEY: I do. I have a fellowship in pre-hospital  
 22 care in addition to my fellowship in anaesthesia and  
 23 I have a PhD in defence and security, which was an  
 24 exploration of ballistic head injury.  
 25 Q. It is relevant to note that you joined the

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1 Territorial Army in 1980?  
 2 COLONEL MAHONEY: I did. So I joined the Territorial Army  
 3 as a student in 1980 and have seen continuous service up  
 4 until this point. My deployed service included multiple  
 5 deployments to both Iraq and Afghanistan, where I was  
 6 actively involved in the clinical management of  
 7 casualties suffering from blast and ballistic injury.  
 8 I have an additional qualification which is  
 9 a postgraduate diploma in forensic investigation.  
 10 Q. So the simple point is that you have extremely extensive  
 11 experience of treating blast injuries arising in  
 12 a battlefield context?  
 13 COLONEL MAHONEY: That is correct.  
 14 Q. I'm going to turn next to the professor, unless you have  
 15 anything you wish to add about your background and  
 16 experience.  
 17 COLONEL MAHONEY: Nothing else, thank you.  
 18 Q. Obviously, no one could doubt the expertise of the two  
 19 of you in the issues you're going to help us with.  
 20 Professor, I'm going to ask you next to assist us  
 21 with the background and qualifications of the three  
 22 additional members of the panel, albeit we'll hear from  
 23 them in due course. It's helpful to know about it at  
 24 this stage.  
 25 First of all, could, you tell us about Professor,

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1 also Colonel, Jon Clasper? I'm at page 33 of your  
 2 report.  
 3 PROFESSOR BULL: Jon Clasper is the former defence professor  
 4 of trauma and orthopaedics. He is a consultant  
 5 orthopaedic surgeon, also retired now from the military.  
 6 Q. But I think recently retired?  
 7 PROFESSOR BULL: Recently retired. He has seen significant  
 8 deployments, operational experience, in many places,  
 9 including Afghanistan. He is a research-active  
 10 orthopaedic and trauma surgeon with extensive expertise  
 11 in blast injuries, particularly to the extremities, as  
 12 relevant to his orthopaedic practice. He has led on the  
 13 clinical aspects of the Centre for Blast Injury Studies  
 14 since its inception and so has far broader expertise  
 15 in that domain and he's a fellow of the Royal College of  
 16 Surgeons of Edinburgh and of England.  
 17 Q. That's extremely helpful. Next, the fourth member of  
 18 the panel, Alan Hepper, please.  
 19 PROFESSOR BULL: Alan Hepper is an engineer. He is a  
 20 principal engineer at DSTL, the Defence, Science and  
 21 Technology Lab at Porton Down. In that role, he is the  
 22 lead on human vulnerability, injury assessment and  
 23 injury modelling. He has extensive experience of expert  
 24 witness to the Special Investigation Branch and others  
 25 and he has been an expert witness on things such as the

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1 7/7 bombings and the Birmingham pub bombings in 1974.  
 2 He brings expertise in both the physical aspects of the  
 3 explosion but also extensive expertise in the human  
 4 injury aspects.  
 5 Q. And has, I think, also from my own meeting with him,  
 6 very extensive understanding of various data which bears  
 7 upon the work that you do?  
 8 PROFESSOR BULL: That's correct, specifically in terms of  
 9 injury scoring, which is something that I will mention  
 10 later on, which is how you capture the injuries of  
 11 individuals in a rigorous way that is comparable to  
 12 other data sets.  
 13 Q. And then finally, and once we've dealt with the fifth  
 14 expert, I'm going to asking you about how the five of  
 15 you have worked together, Lieutenant Colonel, also  
 16 Doctor, Mark Ballard, please.  
 17 PROFESSOR BULL: Mark Ballard is a practising radiologist.  
 18 He is the defence consultant adviser in radiology, so  
 19 the senior radiologist in the military. He is a head  
 20 and neck imaging specialist as well as a trauma imaging  
 21 specialist. He has also deployed to Afghanistan in his  
 22 military role and he was one of the three radiologists  
 23 who reported on the CT post-mortems for the victims of  
 24 the Manchester Arena bombing as well.  
 25 He has expertise in many relevant areas, most

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1 notably imaging, but also has published on areas such as  
 2 the use of tourniquets.  
 3 Q. Just to summarise in a few sentences what each of you  
 4 has brought to the analysis. Colonel Mahoney, would it  
 5 be fair to summarise your expertise as being the  
 6 pre-hospital aspect of our analysis?  
 7 COLONEL MAHONEY: Pre-hospital aspects and the clinical  
 8 effects of explosive injury.  
 9 Q. Indeed.  
 10 Professor Clasper, again seeking to capture this in  
 11 a few words, but if I don't do it justice, you must tell  
 12 me, what he has brought to your analysis in particular  
 13 is his expertise in surgery?  
 14 PROFESSOR BULL: And in extremity injuries and bleeding,  
 15 which is relevant to this subject matter.  
 16 Q. Lieutenant Colonel Dr Ballard, the particular expertise  
 17 that he has brought to bear relates to the radiological  
 18 aspects of the cases?  
 19 PROFESSOR BULL: That's correct.  
 20 Q. Professor, the expertise that you have brought to bear  
 21 relates to the physical aspects of what happens in an  
 22 explosion?  
 23 PROFESSOR BULL: And its relationship to the injuries that  
 24 arise.  
 25 Q. And that Alan Hepper's expertise is complementary to

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1 your own, would that be fair?  
 2 PROFESSOR BULL: Including specifically the injury scoring  
 3 aspects.  
 4 Q. Thank you very much indeed. That is a most helpful  
 5 introduction to the five of you.  
 6 In terms of your substantive evidence, I'm going to  
 7 turn first of all to you, Professor Bull. I'm going to  
 8 ask you first of all to identify for us what issues you  
 9 were instructed to assist the inquiry in respect of.  
 10 PROFESSOR BULL: We were to describe a description of blast  
 11 injuries, classifying terms carefully that would then be  
 12 of use to us as we go forward, describing environmental  
 13 effects and describing the management of blast injuries.  
 14 We additionally and critically, not included today,  
 15 included a section on survivability for each fatality.  
 16 To be clear, we weren't asked if the clinical treatment  
 17 for each individual should have been different; we were  
 18 asked to comment on survivability only.  
 19 Q. Yes. As you have rightly identified, that's a part of  
 20 your evidence that we're going to leave until you return  
 21 in order to give your evidence later in chapter 12.  
 22 Thank you very much.  
 23 In terms of your substantive evidence, in your  
 24 report, and I'm going to start at page 4, you help with  
 25 the definition of various terms. But the critical

1 feature that we need to understand relates to the  
 2 explosive effects of a blast.  
 3 The report descends into considerable detail, but as  
 4 you'll appreciate, we need to avoid being technical to  
 5 the extent possible to communicate your evidence,  
 6 although I do understand that that will not be entirely  
 7 possible. So professor, I believe that it's to you that  
 8 I should turn to help us with the explosive effects of  
 9 a blast.  
 10 PROFESSOR BULL: Yes. So if I may, I'll start with the seat  
 11 of the explosion where the explosion takes place.  
 12 Fundamentally, there are two key things that happen  
 13 almost simultaneously. The first is that the explosion  
 14 produces an extremely high pressure wave. So if you  
 15 imagine a balloon that is blown up and tied, that  
 16 balloon contains energy within it, and once the balloon  
 17 is popped, that energy is released, where the pressure  
 18 goes out from that centre in a spherical way, so it goes  
 19 out radially and equally in all directions and it  
 20 carries with it the air and the detonation products, if  
 21 there are any. It carries that with it behind that  
 22 pressure wave. So the material that is carried, the  
 23 air, is called the blast wind, and the wave of pressure  
 24 that goes ahead of that is called the shock wave or the  
 25 pressure wave. So you have this high pressure and then

1 you have this mass of material, air, which is  
 2 a material, that moves directly behind that.  
 3 The pressure wave --  
 4 Q. Can I ask you to pause for one moment? I will do so  
 5 from time to time. A note is being made by various  
 6 people and also I need to make sure that I understand  
 7 two things, a number of things.  
 8 So where an explosion occurs, what is created may be  
 9 known collectively as the blast wave?  
 10 PROFESSOR BULL: That's correct, and that is the combination  
 11 of the shock wave at the front and the blast wind that  
 12 carries the material behind it.  
 13 Q. In case we hear other terms being used, the shock wave,  
 14 is that also sometimes known as the shock front and  
 15 sometimes known as the detonation wave?  
 16 PROFESSOR BULL: That's correct.  
 17 Q. But we can be clear, these two component parts, the  
 18 shock front and the blast wind, are known together as  
 19 the blast wave?  
 20 PROFESSOR BULL: That's correct.  
 21 Q. So I've understood so far. Thank you. Could you carry  
 22 on?  
 23 PROFESSOR BULL: So the features of that are that there is  
 24 a very rapid increase in pressure at that front, at that  
 25 shock wave, and that dramatic increase in pressure

1 occurs within a couple of milliseconds normally. So  
 2 then you achieve a peak pressure and that peak pressure  
 3 is a function of many things, but primarily the  
 4 explosive device itself.  
 5 Then we need to bring in the environment here. So  
 6 in an open environment, a free-field environment, if an  
 7 explosion were to take place a few metres off the  
 8 ground --  
 9 Q. So free-field is a technical description that is  
 10 describing an environment which is entirely open?  
 11 PROFESSOR BULL: Which is entirely open and it is purely  
 12 theoretical because it also assumes that there's no  
 13 ground there.  
 14 So the pressure wave moves out radially in all  
 15 directions equally. It's an extremely high pressure,  
 16 but it dissipates very quickly. It dissipates in two  
 17 ways: by distance and by time. So if one is close, if  
 18 there is an object close to the seat of the explosion,  
 19 that object will experience an extremely high peak in  
 20 pressure and very quickly, within a few milliseconds,  
 21 that pressure will dissipate fully if one is close. If  
 22 one is further away, the peak pressure will be far lower  
 23 and it will also dissipate but a little bit more slowly.  
 24 So you have this combination of time and distance  
 25 and the distance is critical and so I will just explain

1 very briefly and do stop me if this becomes a little too  
2 technical.

3 By example, if you are 1 metre from the seat of the  
4 explosion, and the pressure is, say, 8 kilopascals or  
5 a number of 8 higher than normal pressure, let's use  
6 that number, and you're 1 metre away, if you go to  
7 2 metres away, that will reduce to only 1 times normal  
8 pressure, 1/8. And that is called a cube law. So it's  
9 the radius, the distance, times itself, times itself  
10 again. So if we go from 1 metre, it's 1 times 1 times  
11 1, the pressure is 8. If you go 2 metres, it's 2 times  
12 2 times 2, it's 1/8 of the original pressure.

13 Q. Is it too simple to say that the further away from an  
14 explosion one is, the less likely one is to be affected  
15 by it?

16 PROFESSOR BULL: Yes.

17 SIR JOHN SAUNDERS: So it is too simple?

18 PROFESSOR BULL: It is a little too simple, yes, correct,  
19 because it dissipates more quickly. So if one is close,  
20 the pressure is experienced by the object. It very  
21 quickly dissipates, so if one is 4 metres away, or one  
22 is 8 metres away, for both of those it may already have  
23 dissipated so significantly that it's negligible. So it  
24 ramps up very quickly the closer you get, in this cube  
25 power.

13

1 That's important when we talk about other types of  
2 blast injuries, that specific value, this 1/8 value.

3 MR GREANEY: The blast wave is made up of these two  
4 components and you've spoken of an object being affected  
5 by it. Obviously, we are talking here about people, but  
6 let's just restrict ourselves to an object at the  
7 moment. Do those two different component parts of the  
8 blast wave, the shock wave and the blast wind, impact  
9 upon that object in different ways or in combination to  
10 the same effect?

11 PROFESSOR BULL: I will describe them in combination to the  
12 same effect, but very specifically with primary blast  
13 that we will describe later, it is slightly different,  
14 so I will refer to that when I get to primary blast.

15 Q. Shall we leave that until that stage?

16 PROFESSOR BULL: Thank you. The first is the distance  
17 effect. The second is the time effect, this dissipation  
18 due to time. That's very important because in  
19 a free-field, in this open environment, this idealised  
20 pressure wave that one would understand for a blast,  
21 you have a rapid peak and then it dissipates really  
22 rather quickly. So the area under that curve, if  
23 you are to think of pressure and time, is a measure of  
24 the impulse or energy that is deposited into an object  
25 that comes in the way of that blast wave.

14

1 Because the peak is very high, but it dissipates  
2 quickly, the energy deposited is relatively low unless  
3 there are environmental effects. And by that, I mean  
4 that we move from the idealised, open, free-field  
5 scenario to perhaps something like an enclosed scenario.  
6 So if that balloon were inside a contained space that is  
7 closed and that is quite small, relative to the size of  
8 the balloon, and the pressure were to increase  
9 dramatically when the balloon pops, the explosion  
10 happens, there are reflections of that pressure wave off  
11 the side of the container, off the side of the enclosed  
12 environment that the explosion takes place in.

13 Q. And off the ground and the roof, I suppose, as well?

14 PROFESSOR BULL: And off the ground and the roof. That  
15 serves to do two things. The first thing is it changes  
16 the curve, the pressure/time curve from a peak and rapid  
17 decay into a peak and multiple reflections, and  
18 secondly, that means that the area under the pressure  
19 time curve is much, much greater than the idealised and  
20 so there is far more significant energy deposited into  
21 an object that is in its environment. That also means  
22 that the peak pressure is maintained for longer and for  
23 further from the seat of the explosion.

24 Q. So I did tell you that from time to time we would need  
25 to focus in on Manchester Arena and on the City Room.

15

1 You have described free-field and enclosed space.

2 Obviously, the City Room is enclosed in one sense, but  
3 when we come on later in your evidence to consider  
4 environmental factors, should we regard the City Room as  
5 being an enclosed space or as something different?

6 PROFESSOR BULL: Okay. So for it to be an idealised  
7 enclosed space, the pressure would have to be contained.  
8 And that was not the case in the arena, first.

9 Secondly, the pressure would have to — the volume  
10 within which the pressure could be dissipated would have  
11 to be small enough for it to have a significant effect,  
12 and the arena is very large. So based on our expertise,  
13 we would class this more akin to an open, free-field  
14 type of blast rather than an enclosed blast, even though  
15 it occurred within a building.

16 Q. So far, we have been talking about a balloon and  
17 a balloon popping. Obviously, we are here concerned  
18 with something far more terrible than that and I want to  
19 move next to understand a bomb of the type that we are  
20 concerned with and how that relates to the kind of  
21 issues you have been telling us about. I am at page 8,  
22 I think, of your report.

23 SIR JOHN SAUNDERS: Do you mind if I just ask one thing?  
24 This is probably a very naive question, so please  
25 forgive it. You have talked about a shock wave and

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1 a blast wind being these two components and, obviously,  
 2 the blast wind is made up of air. Is the shock wave  
 3 made up of anything?  
 4 MR GREANEY: I think we're coming to that, sir.  
 5 SIR JOHN SAUNDERS: Thank you. Okay.  
 6 MR GREANEY: It's an entirely sensible question, but  
 7 I promise we are coming to it.  
 8 SIR JOHN SAUNDERS: That's entirely fine. Deal with it in  
 9 your own way.  
 10 PROFESSOR BULL: The shock wave is the transmission of  
 11 energy through the material, so the material is the air  
 12 but it's not necessarily moving air. One can understand  
 13 that in the context of maybe a piece of metal, and if  
 14 one were to strike a piece of metal, the metal itself is  
 15 not moving anywhere, but there is, as you would hear,  
 16 some resonance, there is a wave transmitted through that  
 17 piece of metal. Effectively, that's happening with the  
 18 shock.  
 19 So the shock is the pressure being deposited through  
 20 that, but it's not the energy being brought through,  
 21 which is the mass of air behind it. So it's the way  
 22 pressure is transmitted through a material. It can  
 23 happen through glass, it can happen through metal, it  
 24 can happen through air and water as well.  
 25 Q. I have probably entirely misunderstood this, and

17

1 if I have you'll tell me, but the blast wave is itself  
 2 capable of causing injury, the ways in which you're  
 3 going to come on to describe?  
 4 PROFESSOR BULL: Yes.  
 5 Q. The shock wave, rather, is capable of causing injury --  
 6 PROFESSOR BULL: Yes.  
 7 Q. -- in ways you're going to describe. But the shock wave  
 8 itself, if there has been a bomb of the type we are  
 9 concerned with, that will not carry the fragments?  
 10 PROFESSOR BULL: No. Should I explain that?  
 11 Q. Please do.  
 12 PROFESSOR BULL: The blast wind that comes behind the shock  
 13 wave carries material with it, explosive products,  
 14 et cetera, the air. But there are also fragments, so  
 15 some fragments come from the device itself, these are  
 16 called primary fragments, and some fragments might be  
 17 from the environment around it that are energised by  
 18 this blast wind and those are called secondary  
 19 fragments. But we have fragments, we have material  
 20 that is energised by the blast wind, and this is then  
 21 carried radially again, because the energy is going out  
 22 in the same way, so equally in all directions in an open  
 23 field environment and travels distance.  
 24 What is different is, because of the way the laws of  
 25 physics work, that the energy that is contained within

18

1 one of those fragments now, so energy is deposited into  
 2 a fragment, it is accelerated and it is transmitted out  
 3 radially. It now has its own energy, kinetic energy,  
 4 moving energy. That dissipates over time as well, so if  
 5 one were to fire a gun with a certain velocity, it would  
 6 reduce its velocity over time, over distance.  
 7 The amount of energy that it loses is slower than  
 8 the amount of energy that is lost by the shock wave. So  
 9 if one were to double the distance, the energy it holds  
 10 is now one quarter, whereas for the pressure wave, for  
 11 the shock wave, it is one eighth. That's key. So what  
 12 it means is that the fragments can cause harm to an  
 13 object at a far longer distance from the seat of the  
 14 explosion than the shock wave itself in a radial  
 15 direction, with direct line of sight.  
 16 Q. I'm going to turn in a moment to look, as is very  
 17 important, at the type of injuries that may be caused by  
 18 an explosion. But what I'm going to do before we turn  
 19 to that is to see if I can express the evidence you've  
 20 given in a few simple propositions and, again, if  
 21 I oversimplify this you must tell me because I do tend  
 22 to do that.  
 23 An explosion generates high pressure, which is  
 24 transferred into the surrounding area?  
 25 PROFESSOR BULL: Yes.

19

1 Q. That high--pressure front travels out very quickly  
 2 indeed, indeed quicker than the speed of sound?  
 3 PROFESSOR BULL: Correct.  
 4 Q. We might describe that as the blast wave?  
 5 PROFESSOR BULL: Yes.  
 6 Q. That blast wave has two components: the shock front and  
 7 the blast wind?  
 8 PROFESSOR BULL: Yes.  
 9 Q. And that blast wave lasts for a very short period of  
 10 time, we're talking thousandths or hundredths of  
 11 a second?  
 12 PROFESSOR BULL: Correct.  
 13 Q. Where the explosion is the result of an explosive  
 14 device, on explosion the device will fragment?  
 15 PROFESSOR BULL: Correct.  
 16 Q. And the fragments of the device and anything with which  
 17 it is packed, in this case, as we know, with nuts, will  
 18 be thrown out, and we would describe those as being  
 19 primary fragments?  
 20 PROFESSOR BULL: Correct.  
 21 Q. But also, the effect of the blast wave may be to move  
 22 other items which are within its environment?  
 23 PROFESSOR BULL: Yes.  
 24 Q. So a stone, for example?  
 25 PROFESSOR BULL: Correct.

20

1 Q. And those will be described as secondary fragments?  
 2 PROFESSOR BULL: Yes.  
 3 Q. So have I understood so far?  
 4 PROFESSOR BULL: Yes, you have.  
 5 Q. And have I oversimplified where we have reached?  
 6 PROFESSOR BULL: I think that's sufficient.  
 7 Q. I'm going to turn next to page 9 of your report, and  
 8 again Professor Bull, in the first instance, you're  
 9 going to help us with this. It's the classification of  
 10 blast injuries. And then we'll turn to the colonel to  
 11 help us with the medical effects unless, sir, there are  
 12 any further questions you have about the physical  
 13 aspects of an explosion.  
 14 SIR JOHN SAUNDERS: No, thank you.  
 15 MR GREANEY: Again, over to you in the first instance,  
 16 professor, and at the end I will see if I can apply some  
 17 simplification if it has become complicated.  
 18 Could you explain to us the five main categories of  
 19 blast injuries, albeit I do appreciate in relation to  
 20 the fifth there is controversy.  
 21 PROFESSOR BULL: It may be helpful to bring up figure 3.  
 22 Q. Indeed, yes. Could we have, please, Mr Lopez, on the  
 23 screen — and don't put it up until you have focused in  
 24 on the figure — figure 3. This is {INQ025364/9}.  
 25 If you can just have the figure on the screen, that

1 would be extremely helpful.  
 2 Just before you put it on the screen, sir, could  
 3 I just make sure everyone is aware, this is an image  
 4 that we did look at on the screen during the course of  
 5 our opening statement back in September of 2020. It is  
 6 not overly graphic, but it does demonstrate what happens  
 7 in an explosion and I just wanted to give that warning  
 8 to everybody before we see it. It doesn't show real  
 9 life, but it does show the effects of an explosion.  
 10 The phases and the categorisation of blast injuries,  
 11 please, professor.  
 12 PROFESSOR BULL: Yes. We will start with primary blast  
 13 injury. This peak pressure, the shock wave, that is  
 14 transmitted, I think it's helpful to explain again in  
 15 terms of a bar of metal. If the pressure wave, if one  
 16 hits the bar of metal at one end, the shock wave, a  
 17 wave, is transmitted through that metal and in and of  
 18 itself it is not damaged.  
 19 However, if one were to have a material placed on  
 20 the end of that bar of metal, maybe another rod, maybe  
 21 some other material, and one were to hit that bar of  
 22 metal and the wave were to be transmitted along it, then  
 23 the material at the end would separate from it, the  
 24 material that was in contact with it.  
 25 So what happens when a shock wave comes into contact

1 with an object, and with a person in this case, the  
 2 first material that it comes into contact with, let's  
 3 say the skin, the muscle, the tissues, have the pressure  
 4 wave transmitted through it. But where the tissues have  
 5 a margin between them, so let's say between muscle and  
 6 bone, or let's say between air and the tissues of the  
 7 lung, then, like the metal bar and the material placed  
 8 on the end of it, there is disruption at the interface,  
 9 the pressure wave goes through and then where you have  
 10 an interface, there is shearing, a separation of the  
 11 materials at that interface.  
 12 That's particularly significant where you have  
 13 materials of very significant density such as bone and  
 14 air, fluid and soft tissues. They have different  
 15 densities and so you end up with disruption at those  
 16 interfaces, so that disruption is a primary blast  
 17 injury.  
 18 Q. So we are not talking here about the object, a person,  
 19 being struck by any fragment of a bomb, we're just  
 20 talking about the shock wave?  
 21 PROFESSOR BULL: It's that peak pressure that occurs for  
 22 a very short period of time in a free-field environment,  
 23 which is what we're talking about, an extremely short  
 24 period of time. If the person is close to the seat of  
 25 the explosion, then that pressure wave is transmitted

1 through the person and at the interfaces there is  
 2 disruption and shearing of the tissues.  
 3 Q. You talk about shearing of tissues.  
 4 PROFESSOR BULL: Tearing.  
 5 Q. So the shock wave itself, as we're going to hear from  
 6 Colonel Mahoney in due course, is capable of causing  
 7 injury, indeed serious injury?  
 8 PROFESSOR BULL: Yes.  
 9 Q. And in this context we're going to look with the colonel  
 10 in due course at, for example, blast lung. So that is  
 11 primary blast injury caused by the shock wave itself?  
 12 PROFESSOR BULL: And I think it's worth clarifying here that  
 13 there is confusion in many places where people refer to  
 14 "blast injury" in general but mean primary blast injury.  
 15 However, the subsequent blast injury mechanisms that  
 16 I will refer to now are also included under that, and we  
 17 just need to be careful.  
 18 Q. You refer to this in your report. There is an issue of  
 19 terminology. When you use the term "blast injury", you  
 20 are describing primary through to quinary. But  
 21 sometimes in the literature, "blast injury" is used to  
 22 describe what is more precisely described as primary  
 23 blast injury?  
 24 PROFESSOR BULL: That's correct.  
 25 Q. So we will be careful about our terminology.

1 SIR JOHN SAUNDERS: Just before you go on from primary blast  
 2 injury, in the case of the City Room are we considering  
 3 reflecting shock waves as well as —  
 4 PROFESSOR BULL: No, we're not.  
 5 SIR JOHN SAUNDERS: So we can, as it were, delete "and  
 6 reflecting shock waves" because, although it is part of  
 7 the principle, it doesn't actually apply in this case?  
 8 PROFESSOR BULL: That's correct, sir.  
 9 MR GREANEY: When you return, we are going to look at the  
 10 actual relevance of primary blast injury in our  
 11 circumstances, but now I hope we do understand what  
 12 primary blast injury is: these are the injuries caused  
 13 by the shock wave itself and we'll understand that from  
 14 a medical perspective in a short time.  
 15 Can we turn next, then, to secondary blast injury?  
 16 PROFESSOR BULL: So the blast wind is accelerating these  
 17 fragments, projectiles, effectively, and, if you recall,  
 18 the energy is dissipated more slowly than the peak  
 19 pressure, the shock wave.  
 20 Q. Yes.  
 21 PROFESSOR BULL: Effectively, these cause anatomical  
 22 deficit. They come into contact with the person and  
 23 they disrupt the anatomy: they tear the anatomy, they  
 24 push holes through the anatomy. This is like being hit  
 25 by — being shot, but it's typically worse than that

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1 because the fragments don't only contain energy going in  
 2 a straight line, they also contain rotational tumbling  
 3 energy, which is a function of the shape of these  
 4 fragments, and that tumbling energy causes more  
 5 significant tearing of the anatomy that it comes into  
 6 contact with.  
 7 So very specifically, this is where anatomy plays  
 8 a major role in blast injuries because it's always very  
 9 specific to the very specific projectile and the very  
 10 specific anatomy that it has disrupted.  
 11 Q. So obviously, being struck by a primary and secondary  
 12 fragment is going to be terrible, a terrible event  
 13 whatever, but if one is struck in the head or in the  
 14 heart, that is inherently going to be more serious than  
 15 being struck in another part of the body or other parts  
 16 of body?  
 17 PROFESSOR BULL: Yes, that's correct, and Colonel Peter will  
 18 be referring to that later on. I think it is worth just  
 19 highlighting that there is this line of sight issue,  
 20 where clearly if there are objects between the explosion  
 21 and the individual, then one can imagine that there  
 22 isn't an equal statistical chance of being struck by one  
 23 of these fragments. The explosion may not be perfectly  
 24 detonated and so the pressure may be slightly higher on  
 25 one side on the other, there may be little peaks of

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1 pressure that then accelerate fragments in one direction  
 2 more than another, so it's not just a perfect situation  
 3 in general.  
 4 So these fragments can travel a very long distance,  
 5 but they may only travel a very long distance in one way  
 6 and not in the other way.  
 7 Q. When we talk of secondary blast injury, we're talking  
 8 not just of injury caused by primary fragments of a bomb  
 9 in this case, but also what you've explained to us as  
 10 secondary fragments as well?  
 11 PROFESSOR BULL: That's correct.  
 12 Q. I'm just going to pause for a moment. I am aware that  
 13 some have left the room, which I completely understand.  
 14 As I explained yesterday, I recognise that this  
 15 evidence, which is being expressed in technical terms,  
 16 but which has caused enduring loss to so many, is  
 17 inevitably going to be distressing. I regret that, but  
 18 see no other way of doing it.  
 19 SIR JOHN SAUNDERS: There is no alternative. It has to be  
 20 gone through, as everyone accepts, and you have  
 21 indicated and pre-warned people, which is I think all  
 22 that can be done. What might be helpful now, if you're  
 23 able to say so, is to give some rough idea of how long  
 24 this evidence is likely to take before we get on to the  
 25 next stage when people might wish to come back.

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1 MR GREANEY: Sir, I think that this evidence will take until  
 2 no later than midday, that's my prediction.  
 3 I anticipate that Ms Cartwright will provide the  
 4 information she wishes to provide at some stage before  
 5 we break for lunch at 12.30, so if we set a time now of  
 6 12.15, and then we will commence the evidence in  
 7 chapter 12 at 1.30.  
 8 SIR JOHN SAUNDERS: Thank you very much.  
 9 I wonder if people could convey that to — the  
 10 family CPs can convey that to the various people who  
 11 have perfectly reasonably left.  
 12 MR COOPER: Of course, sir. I can reassure all within the  
 13 hearing that all family CPs, I know, have spoken very  
 14 carefully with their clients who attend to endorse what  
 15 has been said. Whether perhaps a few more breaks than  
 16 normal in proceedings might help so that we could speak  
 17 with families who may be upset, I'll leave that to the  
 18 discretion of the inquiry.  
 19 SIR JOHN SAUNDERS: Okay.  
 20 MR GREANEY: That sounds like a sensible invitation to have  
 21 a short break at this stage and I'm very grateful to  
 22 Mr Cooper for helping us to manage this in a sensitive  
 23 and helpful way.  
 24 SIR JOHN SAUNDERS: Okay. If we have our quarter of an hour  
 25 break, that would be a good idea.

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1 I'm sorry to interrupt your evidence, I'm sure  
 2 you'll understand. Thank you.  
 3 (10.24 am)  
 4 (A short break)  
 5 (10.39 am)  
 6 MR GREANEY: Sir, thank you, we're going to continue with  
 7 the classification of blast injuries. I'm going to ask  
 8 that we have back on the screen figure 3, please, and  
 9 that the professor then helps us in relation to tertiary  
 10 injuries, please.  
 11 We've dealt with primary and secondary. What are  
 12 tertiary injuries as a result of a blast, please?  
 13 PROFESSOR BULL: If we just refer back to the concept of  
 14 energy being deposited into an object, there are  
 15 injuries that occur when someone themselves has the  
 16 energy deposited, almost like a blunt deposit, so they  
 17 are then displaced by the blast wind. And do that  
 18 displacement can be very rapid in some instances and  
 19 therefore, as they are displaced, they can have  
 20 accelerative injuries that could be due to internal  
 21 accelerations or they can have crush injuries, where  
 22 they come into contact with something hard. That is one  
 23 form of tertiary blast injury.  
 24 Another form of tertiary blast injury is sometimes  
 25 called solid blast and that is when something else has

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1 been energised, it might be the environment itself, it  
 2 might be the building, and large material, not fragments  
 3 any more, but large material comes into contact with the  
 4 individual. That then also produces crush injuries. So  
 5 either the individual comes into contact with something  
 6 hard or something hard comes into contact with the  
 7 individual.  
 8 SIR JOHN SAUNDERS: When you're moving the body, is that  
 9 caused by the blast wind?  
 10 PROFESSOR BULL: Yes, it's caused by the blast wind as the  
 11 mass of air energises the individual.  
 12 SIR JOHN SAUNDERS: Because the shock front passes through?  
 13 PROFESSOR BULL: Has gone through, yes, that's correct.  
 14 Just to be clear, and maybe Colonel Peter will comment  
 15 on this, the energy involved is far higher than one  
 16 would see in, for example, a road traffic accident or  
 17 something like that. So these crush injuries can be far  
 18 more severe in tertiary blast.  
 19 SIR JOHN SAUNDERS: Okay. I may be being unduly optimistic  
 20 but that seems a fairly simple concept to me as compared  
 21 perhaps to the primary blast injury, which is more  
 22 difficult to understand.  
 23 MR GREANEY: I agree, sir, although hopefully we understand  
 24 each of them so far.  
 25 That's all I want to ask you about tertiary blast

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1 injury. Quaternary blast injury, please.  
 2 PROFESSOR BULL: This is relevant. It's caused by heat and  
 3 clearly when you have an explosion, heat is given off,  
 4 and so burns and inhalation injuries can occur. This is  
 5 also a more straightforward concept.  
 6 Q. And then finally, the concept over which I know there is  
 7 some controversy, quinary blast injury, please.  
 8 PROFESSOR BULL: Yes. There are different ways of  
 9 describing this, but perhaps we could describe it most  
 10 simply as all the other types of injury that could occur  
 11 due to blast. For example, biological injury where  
 12 there may be biological contaminants or radiological  
 13 injury where there are radiological contaminants. And  
 14 of course these effects can be immediate but they can  
 15 also be long term.  
 16 SIR JOHN SAUNDERS: Do we need to go into why this is  
 17 controversial?  
 18 MR GREANEY: I think you can probably express it in a couple  
 19 of sentences, in the way in which you do in your report.  
 20 PROFESSOR BULL: I think because some people would say that  
 21 because certain of the injuries that I have just  
 22 described, let's say radiological, they don't appear  
 23 directly as a result of something that is associated  
 24 with the blast wave or the blast wind, it's more the  
 25 contaminants, and so people would then not describe that

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1 as a blast injury. But because it occurred due to the  
 2 explosion, others would class it as such.  
 3 SIR JOHN SAUNDERS: So whether you call it a blast injury or  
 4 something different, it's still an effect of a blast  
 5 taking place?  
 6 PROFESSOR BULL: Yes, sir.  
 7 MR GREANEY: It's kind of a direct/indirect type issue?  
 8 PROFESSOR BULL: That's correct.  
 9 Q. Although, I think in fact, as we are going to learn when  
 10 you return, that's not really something that we need to  
 11 be concerned go in the context of the Manchester Arena  
 12 attack.  
 13 PROFESSOR BULL: No, not specifically.  
 14 Q. In your report, you deal with environmental features and  
 15 device proximity in considerable detail. Obviously, in  
 16 dealing with this we need to be very alert to the need  
 17 not to provide information of assistance to those who  
 18 would wish us harm. Is there any particular feature  
 19 that falls under that heading, environmental features  
 20 and device proximity, that you believe it is important  
 21 to draw to our attention that we have not dealt with so  
 22 far?  
 23 PROFESSOR BULL: I don't think so.  
 24 Q. Nor do I. So professor, I'm going to turn from you,  
 25 please, for the time being, to Colonel Mahoney.

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1 Colonel, I'm going to ask you to deal with what  
 2 again will be a distressing aspect of the evidence for  
 3 in particular the bereaved families, so I give that  
 4 warning. I'm going to ask you to help us with the  
 5 medical aspects of each of those types of blast injury  
 6 which Professor Bull has described to us in physical  
 7 terms.  
 8 I'm at page 9 of your report. So first of all,  
 9 primary blast injuries. What type of injuries from  
 10 a medical perspective are we concerned with here?  
 11 COLONEL MAHONEY: If I may, I think it would be very helpful  
 12 to start with a description of fundamental physiology.  
 13 Q. That would indeed be helpful, thank you.  
 14 COLONEL MAHONEY: If we think about what we need to be alive  
 15 as human beings, fundamentally we need oxygen and other  
 16 vital nutrients delivered to the cells or key organs.  
 17 So I need oxygen delivered to the cells in my brain. To  
 18 do that I need blood, I need blood flowing in intact  
 19 blood vessels. And for the blood to flow, I need  
 20 a heart that's pumping. And then to get oxygen into the  
 21 blood, I need lungs that are working. So that  
 22 fundamental physiology is what's keeping us alive.  
 23 Q. So that's very important to understand in terms of the  
 24 injuries that you're going to describe?  
 25 COLONEL MAHONEY: Yes.

1 Q. And moreover, it's very important, very, very important,  
 2 to understand in terms of how those injuries are to be  
 3 managed if life is to be preserved?  
 4 COLONEL MAHONEY: Yes, it is.  
 5 Q. Thank you very much for providing us with that context.  
 6 Against that background, are you content now to turn to  
 7 deal with these different classifications of injuries  
 8 and what they mean medically?  
 9 COLONEL MAHONEY: Yes, I am. When we're talking about  
 10 primary blast injury, we're particularly concerned with  
 11 the effect that has on the lungs and, as has been  
 12 described by Professor Bull, we're talking about energy  
 13 being delivered into the body and the effect of that  
 14 energy is to sort of pull and push the delicate  
 15 structures of the lungs and disrupt those delicate  
 16 structures, causing bleeding and by causing bleeding  
 17 within the structure of the lungs, the amount of lung  
 18 that is available to exchange oxygen into the body and  
 19 remove carbon dioxide from the body is reduced.  
 20 Q. Just pause for one moment. As I understand it,  
 21 understandably you're focused on the lungs, for reasons  
 22 everyone in this room will understand. But the kind of  
 23 effect you're talking about can occur within any of the  
 24 air-containing organs, so the lungs, airway and bowel?  
 25 COLONEL MAHONEY: It certainly can. And not only that, it

1 can also occur in organs such as the brain. The brain  
 2 is a structure full of lots and lots of complex --  
 3 effectively complex cables and complex cells all working  
 4 together and that same pushing--and--pulling mechanism can  
 5 disrupt the structure of the brain and cause significant  
 6 injury within the brain. So there's the air--containing  
 7 organs that are particularly vulnerable, but you can  
 8 also get energy delivered to other organs.  
 9 Q. Sorry to interrupt you but this is obviously important.  
 10 Are these injuries that can occur without any external  
 11 signs on the body?  
 12 COLONEL MAHONEY: There are injuries that can occur without  
 13 external signs on the body. If you have significant  
 14 lung disruption without obvious external injury, that  
 15 can be caused by a blast wave. You can also get  
 16 significant brain injury without obvious external signs.  
 17 You'd expect to pick those up in subsequent examination  
 18 with CT scans and subsequent post-mortem examination,  
 19 but it is entirely possible, when you're looking at an  
 20 individual lying on the ground in front of you, you  
 21 might not see obvious signs of injury.  
 22 Q. I took you away from the lung. I would like to go back  
 23 to the lung now. Is there a particular type of primary  
 24 blast injury to the lung that is encountered?  
 25 COLONEL MAHONEY: There is a circumstance in which you're

1 likely to find it and that's within closed environments  
 2 because of the increase in pressure as has described  
 3 already.  
 4 Q. Is there is a term that's described to the type of  
 5 injury you're going to tell us about?  
 6 COLONEL MAHONEY: The term that is used is blast lung, which  
 7 again describes the primary injury to the lung. Blast  
 8 lung effectively is a mixture of the bleeding, as I've  
 9 described, and subsequent inflammatory reaction to that  
 10 bleeding.  
 11 SIR JOHN SAUNDERS: Bleeding and? I'm sorry, I missed the  
 12 second part.  
 13 COLONEL MAHONEY: There's the initial injury is bleeding  
 14 caused by disruption of the structure of the lung and  
 15 the result of that is an inflammatory response from the  
 16 body, which means that it becomes a progressive injury,  
 17 an injury that develops over a number of hours and  
 18 becomes worse over a period of time.  
 19 SIR JOHN SAUNDERS: Thank you.  
 20 MR GREANEY: You did mention it, the type of location in  
 21 which that might be more common. I'm going to leave  
 22 that for one moment, we will come back to it.  
 23 Is it possible to express a view about how dangerous  
 24 blast lung is or may that depend upon the particular  
 25 circumstances?

1 COLONEL MAHONEY: It's very situation dependent. So there  
 2 are reports in the open literature of individuals who  
 3 have died purely of blast lung in certain environments.  
 4 And from our own military experience, we have cohorts of  
 5 individuals who have survived blast lung with the  
 6 correct higher-level care. But the key thing to  
 7 remember is in the incident that we are discussing, it  
 8 hasn't happened in isolation, and we have to consider  
 9 the overarching effect of all these injuries taken  
 10 together.  
 11 Q. I entirely understand why you say that and obviously  
 12 we are going to come on to look at that in detail when  
 13 you return.  
 14 SIR JOHN SAUNDERS: So in no case that we are considering  
 15 are we considering an incident of someone dying purely  
 16 from blast lung?  
 17 COLONEL MAHONEY: Correct, sir. No one purely from blast  
 18 lung, sir.  
 19 MR GREANEY: I keep saying this, when you return, we will  
 20 need to look at the preponderance of blast lung amongst  
 21 the 22 people that we are concerned with.  
 22 So a very dangerous condition to suffer from, but  
 23 not necessarily fatal of itself?  
 24 COLONEL MAHONEY: It can be fatal of itself in some  
 25 circumstances, if you're very close to an explosion and

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1 you have a very significant load, which then disrupts  
 2 such a large proportion of the lung there is  
 3 insufficient lung left to allow that oxygen exchange  
 4 that I have described earlier. So it can be a fatal  
 5 injury, but it can also occur in individuals who  
 6 survive. But by virtue of its presence, it will  
 7 interfere with the body's ability to manage the other  
 8 injuries. So in the presence of blast lung, a bleeding  
 9 injury will be more severe because they can compound  
 10 their effects.  
 11 Q. To provide an overall injury profile, which is obviously  
 12 something we're going to have to look at in detail in  
 13 due course.  
 14 There are two further aspects in blast lung, still  
 15 seeking to deal with matters in general terms, and then  
 16 we'll move on to secondary blast injuries.  
 17 SIR JOHN SAUNDERS: Just on the mechanics, in very  
 18 simplistic terms, the mechanics when it does cause death  
 19 on its own, is it's preventing getting enough blood  
 20 in the lungs for the oxygenation of it to go to the  
 21 brain?  
 22 COLONEL MAHONEY: There's a number of reported mechanisms,  
 23 sir, one of which is it's effectively a wholesale  
 24 destruction of the lung tissues, causing tearing and big  
 25 air leaks so the lungs are no longer functioning as

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1 gas-exchange mechanisms. It can be the amount of  
 2 bleeding into the lungs which is impeding the exchange  
 3 of oxygen, and also a proposed mechanism is that gas,  
 4 oxygen, air, particularly air, can be driven through  
 5 ruptured vessels into areas where it shouldn't be. So  
 6 instead of air exchanging across the lung surface, it's  
 7 directly forced into blood vessels and in effect becomes  
 8 what is called an embolism and can go round the  
 9 circulation and cause blockages in vital parts of the  
 10 circulation.  
 11 SIR JOHN SAUNDERS: The essential feature in all of those is  
 12 a prevention of oxygenation of the blood?  
 13 COLONEL MAHONEY: A significant part of the tearing, the  
 14 bleeding and loss of lung function is an impact on the  
 15 ability to oxygenate the blood and the impact of  
 16 embolisation is to prevent circulation to vital parts of  
 17 the body.  
 18 SIR JOHN SAUNDERS: Thank you.  
 19 MR GREANEY: So two aspects before we move on. First of  
 20 all, does it follow from what you have said that  
 21 proximity to the explosion is of a high degree of  
 22 relevance to whether one experiences blast lung and, if  
 23 so, how severely one does so?  
 24 COLONEL MAHONEY: Yes.  
 25 Q. Secondly, you referred to enclosed spaces. Is it of

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1 relevance to whether one suffers blast lung, and if so  
 2 how severely, whether one is in an explosion in an  
 3 enclosed space or elsewhere?  
 4 COLONEL MAHONEY: Yes. If you look at the open source  
 5 literature, there's a higher incidence of casualties  
 6 with blast lung in environments, closed environments,  
 7 such as buses and tube trains.  
 8 SIR JOHN SAUNDERS: And the City Room is not, in your terms,  
 9 a closed environment?  
 10 COLONEL MAHONEY: No, sir, it is not a closed environment.  
 11 So to have blast lung in this context implies  
 12 a proximity to the explosion.  
 13 SIR JOHN SAUNDERS: I understand that.  
 14 MR GREANEY: That's what I wanted to be clear about: the  
 15 fact that we are not concerned about what you describe  
 16 as an enclosed space does not exclude the possibility of  
 17 blast lung, it reduces the prospect of it occurring, but  
 18 obviously one needs to take into account proximity to  
 19 the explosion?  
 20 COLONEL MAHONEY: Yes.  
 21 Q. That's all I wanted to ask you about primary blast  
 22 injury. Is there anything else you'd like to add before  
 23 we move on to secondary blast injury?  
 24 COLONEL MAHONEY: No, thank you.  
 25 Q. Secondary blast injury, please. This is injury

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1 resulting from the impact of fragments. From a medical  
 2 point of view, what injuries does one expect to occur?  
 3 COLONEL MAHONEY: The injuries that you'll get from impact  
 4 of fragments, or the effect that you'll get from the  
 5 impact of fragments, will depend on which part of the  
 6 body is being hit. I appreciate that this -- by  
 7 necessity I have to describe certain injury types.  
 8 Q. We will pause for one moment and I'll fill the gap by  
 9 asking you to confirm that you're moving on to deal with  
 10 what the professor was telling us about earlier, that  
 11 obviously the severity of a secondary blast injury will  
 12 depend upon the location that is struck?  
 13 COLONEL MAHONEY: Absolutely.  
 14 Q. So I've created a pause and thank you very much for your  
 15 caution. You are entirely right that, sadly, we do need  
 16 to understand more about this.  
 17 COLONEL MAHONEY: If we take a fragment, say, that has  
 18 struck somebody in the head, and they suffer  
 19 a significant brain injury, that could be a rapidly  
 20 fatal injury. If we take somebody who has been struck  
 21 by a fragment in the heart or a very big blood vessel,  
 22 that can be a rapidly fatal injury due to disruption of  
 23 the function of the heart or causing rapid bleeding from  
 24 loss of a major blood vessel.  
 25 If a fragment has penetrated the lungs or perforated

1 the lungs, a perforation going all the way through,  
 2 penetrating, entering and not going all the way through,  
 3 then that in itself can disrupt the function of the  
 4 lungs and create an air leak. Indeed in the presence of  
 5 the primary injury, that could compound the effect of  
 6 the primary injury.  
 7 A fragment could impact with a limb and cause  
 8 a breaking of bones and impacting on the individual to  
 9 move, stand up, use their limbs, and if that fragment  
 10 impacts on blood vessels associated with that area of  
 11 the bone, it will also cause bleeding.  
 12 Q. I'm going to ask you to confirm one paragraph of your  
 13 report because I am confident Mr Weatherby would wish me  
 14 to do so. It's at page 10, paragraph 2.32 -- or at  
 15 least part of that paragraph:  
 16 "Injuries that involve the brain or heart are the  
 17 most serious and can cause immediate death. Whereas  
 18 damage to blood vessels or the lungs can cause early  
 19 death, but there may be sufficient time for medical  
 20 interventions to save life."  
 21 COLONEL MAHONEY: Correct.  
 22 Q. "When bone is struck, a fracture can occur but this is  
 23 unlikely to threaten life unless this is associated with  
 24 damage to a major blood vessel."  
 25 COLONEL MAHONEY: Correct.

1 Q. Subject to any questions that the chairman may have,  
 2 that's all I wish to ask you about secondary blast  
 3 injury. Is there anything that you wanted to add before  
 4 we moved on?  
 5 COLONEL MAHONEY: No, sir.  
 6 Q. So next, then, tertiary blast injury. From a medical  
 7 perspective, what sort of injuries would be expected to  
 8 result?  
 9 COLONEL MAHONEY: I think the best way to consider it is  
 10 very much like people falling, impacting with the  
 11 structure or decelerating. So the type of injuries can  
 12 be what we would describe as blunt injuries.  
 13 I mentioned secondary injuries were penetrating or  
 14 perforating --  
 15 MR GREANEY: You did.  
 16 COLONEL MAHONEY: When someone is being thrown either  
 17 against an object or being hit by a large object, you  
 18 would expect to see fractures, you would expect to see  
 19 surface bruising. And if it's hard enough, you might  
 20 also see disruption of internal organs.  
 21 Q. And I think that probably is all we need to say about  
 22 tertiary injuries; do you agree?  
 23 COLONEL MAHONEY: I agree, yes.  
 24 Q. Quaternary blast injury we can deal with swiftly: that  
 25 is injury caused by heat, which may cause burn and/or

1 inhalation injury?  
 2 COLONEL MAHONEY: Yes. It's a result of either burns from  
 3 the products of explosion or burning from other  
 4 materials in the environment being set on fire, such as  
 5 clothing or furniture.  
 6 Q. Then finally, quinary injury. I don't believe we need  
 7 to go into that at all unless you --  
 8 COLONEL MAHONEY: Not for this, sir, no we don't.  
 9 MR GREANEY: I'm going to come on to a connected topic in  
 10 a moment, but sir, that's all I propose to ask about the  
 11 medical aspects of the blast injuries.  
 12 SIR JOHN SAUNDERS: Thank you.  
 13 MR GREANEY: I believe, colonel, that you consider it would  
 14 be helpful for us to understand an issue that you  
 15 address at page 15 of your report. This is your first  
 16 report, your overview report, {INQ025364/15}.  
 17 The heading is:  
 18 "Internal blast injury with no external evidence of  
 19 trauma."  
 20 COLONEL MAHONEY: Yes. We talked briefly about that when  
 21 we were talking about could you have primary blast  
 22 injury or could you have fatal primary blast injury  
 23 without external evidence of injury, and we've covered  
 24 that.  
 25 But in addition, you could have somebody who dies

1 from a very small fragment entering around the hairline  
2 or in through the orbit, and causing brain injury, and  
3 that might not be immediately noticed — or you'd expect  
4 to pick that up perhaps on CT scanning. You could have  
5 small fragments that enter the chest and disrupt the  
6 heart function and you might not see that on initial  
7 external examination, but you would expect to see that  
8 if you did a subsequent CT scan.

9 Q. Next, I'm going to turn to the very important topic of  
10 the management of blast injuries, and again, colonel,  
11 this is a topic for you. I'm at page 17 of your report.

12 Is the basic point that the extent to which lives  
13 may be saved depends upon obviously the nature of the  
14 injury that has been sustained, but also upon the  
15 appropriate and early management of those injuries?

16 COLONEL MAHONEY: Yes, it is.

17 Q. Obviously, some injuries will be, as we're going to  
18 hear, unsurvivable wherever they occur and whatever  
19 treatment is given at whatever stage?

20 COLONEL MAHONEY: Absolutely right. We've talked about  
21 that, we've talked about severe head injuries and direct  
22 injuries to the heart and to major blood vessels where  
23 the injuries are so catastrophic, no intervention will  
24 save that individual. Again, appreciating that this  
25 will be upsetting material, these can be people who are

1 killed instantly or who die within a very short space of  
2 time, and we're talking seconds to minutes.

3 Q. But some injuries, as is obvious, will not be as  
4 catastrophic or as immediately catastrophic as that?

5 COLONEL MAHONEY: That is correct.

6 Q. If the injury one is concerned with is the victim  
7 bleeding badly from an area of the body, what action may  
8 be life-saving?

9 COLONEL MAHONEY: I think what's key is when we're talking  
10 about bomb blasts and ballistic-type injuries, certainly  
11 within the military we had to think in a different way  
12 to the way we were thinking at the beginning of the  
13 conflicts in Iraq and Afghanistan. At the very  
14 beginning of those, we took civilian protocols and  
15 effectively implemented them, but it became very clear  
16 that the prevalence of severe bleeding injury meant we  
17 had to think differently. And the result of that —

18 Q. When did this re-think start?

19 COLONEL MAHONEY: This was from 2003 onwards.

20 Q. Right.

21 COLONEL MAHONEY: Recognising that the sort of penetrating  
22 injury, the perforating injury, the limb-removing injury  
23 of explosions meant we were faced with people who were  
24 bleeding very rapidly and very significantly. So we  
25 moved from a paradigm of standard first aid, which was

1 to manage airway, breathing and circulation, to  
2 a paradigm where we would manage catastrophic bleeding  
3 followed by airway, breathing, circulation.

4 This links with the question you have asked, sir.

5 If you're faced with somebody who is bleeding badly,  
6 with the correct treatment for an injury that's amenable  
7 to stopping bleeding, you can save that person's life.

8 And the correct treatment is simple measures. We're  
9 talking about external bleeding, so somebody bleeding  
10 from an injured arm or injured leg. You may go to  
11 pressure, putting pressure on it to try to compress the  
12 vessels and stop the bleeding, probably go to elevation,  
13 if their injuries allow that, to minimise the blood flow  
14 to that limb, and you may go to a tourniquet.

15 If you're faced with a very severe injury, you may  
16 leap those first two stages and go immediately to  
17 a tourniquet.

18 Q. Is the ability to apply tourniquets dependent upon the  
19 location that the bleed is coming from?

20 COLONEL MAHONEY: Yes, it is. There are some injuries which  
21 are not amenable to treatment with a tourniquet and  
22 there are some that are amenable to treatment with  
23 a tourniquet.

24 Q. So there has been, since 2003, a development of  
25 thinking?

1 COLONEL MAHONEY: Yes.

2 Q. An increase in understanding?

3 COLONEL MAHONEY: Yes.

4 Q. Based sadly upon the fact that the military have  
5 encountered this type of injury all too commonly?

6 COLONEL MAHONEY: Yes.

7 Q. Has the learning that comes from the battlefield been  
8 translated and had it been translated into the civilian  
9 population by 2017?

10 COLONEL MAHONEY: Some of it has. Certainly within the  
11 ambulance services, there was a much greater awareness  
12 of tourniquets and the thought processes of jumping  
13 immediately to a tourniquet under certain circumstances.  
14 And some of the other learning that we brought about,  
15 our resuscitation protocols beyond first aid, have also  
16 come into the National Health Service.

17 Q. The type of bleed that we have been speaking about,  
18 which may or may not be amenable to a tourniquet  
19 depending on location, is postulating an external bleed?

20 COLONEL MAHONEY: Yes.

21 Q. But there may be an injury which results in no or no  
22 significant external bleeding but internal bleeding?

23 COLONEL MAHONEY: Correct.

24 Q. In the context of such a blast injury, how is that to be  
25 managed to save life or with a view to saving life?

1 COLONEL MAHONEY: What we'd look to do would be to either do  
 2 the fundamental basics well, so address any obvious  
 3 external bleeding, address any obvious airway issues,  
 4 any obvious breathing issues, and if the person was not  
 5 responding to that and they had signs of injury,  
 6 recognise the fact that it was likely internal bleeding  
 7 was taking place and aim to evacuate them as quickly as  
 8 possible to a hospital so that they could undergo  
 9 life-saving surgery.  
 10 If you have internal bleeding and you can't deal  
 11 with that at the site of the incident, then really  
 12 you're thinking about doing what you can to keep that  
 13 person stable, but you're looking at a move to  
 14 a hospital to get expert surgical care.  
 15 Q. You mentioned airway and so what one might encounter is  
 16 a situation in which the victim is unconscious and there  
 17 is some blockage in their nose or mouth preventing  
 18 breathing; is that the type of situation we're dealing  
 19 with?  
 20 COLONEL MAHONEY: That's correct. What you could have, you  
 21 could have somebody who had been sucking a sweet before  
 22 they were hurt and that sweet has blocked their airway  
 23 or somebody who's been rendered unconscious and fallen  
 24 in such a position that their tongue is obstructing  
 25 their airway. And what we would look for people

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1 attending the casualty to do would be to carry out  
 2 manoeuvres to unblock the airway, remove any  
 3 obstruction, and position their head, neck, airway in  
 4 such a position that it was then clear and you could  
 5 allow the unimpeded movement of air.  
 6 Q. And the kind of steps to clear any obstruction, are they  
 7 as simple as the steps that I have in my own mind,  
 8 simple steps?  
 9 COLONEL MAHONEY: Yes. Let's say we've got somebody where  
 10 the anatomy has not been injured, so as you look at me  
 11 now, as I look at you, with normal anatomy, then the  
 12 steps are relatively straightforward and are taught as  
 13 part of basic first aid training. We're talking about  
 14 what's called a chin lift, a jaw thrust, and for people  
 15 with more advanced first aid training, they may be  
 16 taught to look in the mouth, look for obstruction, use  
 17 suction apparatus to remove any food or fluid that's  
 18 obstructing. So they are relatively simple procedures  
 19 in the absence of difficult anatomical injury.  
 20 Q. So where we have reached is that in terms of managing  
 21 blast injuries, what needs to occur if there is to be  
 22 a chance of saving life is dealing with a catastrophic  
 23 bleed?  
 24 COLONEL MAHONEY: Yes.  
 25 Q. And managing an airway?

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1 COLONEL MAHONEY: Correct.  
 2 Q. We're going to turn to burden of injury in a moment, but  
 3 before we do is there any other factor or feature that  
 4 you'd like to draw to our attention in relation to the  
 5 management of blast injuries?  
 6 COLONEL MAHONEY: So if an individual had a hole in their  
 7 chest from a fragment and that was impacting on the  
 8 mechanism of breathing, then if somebody had the  
 9 appropriate first aid training, you'd look for them to  
 10 cover that hole.  
 11 Q. So far, we've been speaking about the victim of an  
 12 explosion on the basis that they have one injury, that  
 13 the person managing them has to deal with, but is life  
 14 as simple as that?  
 15 COLONEL MAHONEY: Rarely in explosions, sir, rarely.  
 16 Q. So will, in an explosion, those responding commonly  
 17 encounter victims who have multiple injuries?  
 18 COLONEL MAHONEY: Yes, they will, and that was the situation  
 19 we frequently encountered in Iraq and Afghanistan, which  
 20 is why we developed the paradigm I mentioned earlier of  
 21 the ABC, which was building on first aid knowledge that  
 22 has existed for many, many years, to identify what  
 23 injuries are the most immediately life-threatening,  
 24 manage those quickly, and then move to other injuries.  
 25 So in the presence of multiple injuries, we would

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1 look to identify catastrophic bleeding and deal with  
 2 that and then move on to airway and move on to breathing  
 3 and move on to subsequent injuries.  
 4 But it can be very, very difficult and I think it  
 5 can — if it's not something you have dealt with very  
 6 often, it can be almost overwhelming when you see the  
 7 nature of these injuries.  
 8 Q. I'm going to just read to you one paragraph of your  
 9 report in a moment and invite you to confirm it:  
 10 "The CABc..."  
 11 Can you just remind us what that stands for?  
 12 COLONEL MAHONEY: CABc stands for management of catastrophic  
 13 bleeding, such as that caused by a big injury to a blood  
 14 vessel, where you have catastrophic external obvious  
 15 bleeding, and then moving on to manage airway and then  
 16 breathing issues, then other circulation issues. Other  
 17 circulation issues might be things like less severe  
 18 bleeding. Then you move on through a whole series of  
 19 systems to recognise and deal with other injuries.  
 20 Q. In your report, page 17, paragraph 5.8, you observe in  
 21 connection with this issue of multiple injuries:  
 22 "Whether or not a victim survives being hurt by an  
 23 explosion will depend on the severity of their  
 24 individual injuries and on the combined effect of all  
 25 the injuries they suffer, the overall burden of injury."

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1 COLONEL MAHONEY: Yes, sir, that's correct.  
 2 Q. "It will also depend on any pre-existing medical  
 3 conditions a person has prior to injury, such as heart  
 4 or lung disease, as this may influence how resilient  
 5 they are to the effects of an explosion."  
 6 COLONEL MAHONEY: That's correct.  
 7 Q. So before we leave the question of management of blast  
 8 injuries, and I ask Professor Bull to help us with the  
 9 general approach that the panel took, is the use of  
 10 oxygen something which may be relevant to help badly  
 11 injured people?  
 12 COLONEL MAHONEY: Yes, it is.  
 13 Q. In what ways may that help?  
 14 COLONEL MAHONEY: Well, when I spoke about the physiology  
 15 at the very beginning, I spoke about how we need oxygen  
 16 delivered to our key cells, our key organs. When we  
 17 talk about injury, and loss of blood and loss of lung  
 18 function, we are losing that ability, we're losing the  
 19 ability to carry the oxygen and, with lung injury,  
 20 losing the ability to bring oxygen into the body.  
 21 So effectively, you have an individual who has less  
 22 capacity to bring oxygen in from the air and less  
 23 capacity to move it round the body. Supplementary  
 24 oxygen is a means of trying to compensate for some of  
 25 those losses by increasing the amount of oxygen in the

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1 air the person is breathing and temporarily trying to  
 2 compensate for the fact that they've lost some of the  
 3 usual abilities to deliver oxygen to the body.  
 4 Q. We discussed blast lung earlier. If a person is  
 5 experiencing blast lung, if that's the right way of  
 6 putting it, is oxygen something that would be of  
 7 assistance to them?  
 8 COLONEL MAHONEY: Yes, it would be, because they've lost  
 9 some of the ability of the lung to take oxygen into the  
 10 blood and into the body, so what we're trying to do by  
 11 giving them supplementary oxygen is increase the amount  
 12 of oxygen that's available to the remaining part of the  
 13 lung, and trying to increase the amount of oxygen that  
 14 they're delivering to the body.  
 15 Q. If there has been an explosion and someone has  
 16 a catastrophic bleed, that is or is likely to be obvious  
 17 to someone responding. How is a responder to identify  
 18 that a victim has blast lung so as to know to give them  
 19 oxygen?  
 20 COLONEL MAHONEY: They might not be able to early on.  
 21 That's again one of the fundamental difficulties of the  
 22 type of incident we're describing. Obvious external  
 23 bleeding is relatively straightforward to recognise: you  
 24 can see it, you can see what's in front of you.  
 25 Q. Yes.

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1 COLONEL MAHONEY: With a lung injury, you may be relying on  
 2 a number of more subtle signs, you may be relying on the  
 3 rate the person's breathing at or how hard they're  
 4 breathing, and if it's a conscious person, they may be  
 5 saying, "I'm finding it difficult to breathe", or the  
 6 rate may not be increased -- our experimental work at  
 7 DSTL Porton Down has demonstrated this -- you may not  
 8 get an increase in the rate of breathing. You may not  
 9 get an obvious change in the way somebody's breathing.  
 10 On one hand, it may look very obvious that someone is  
 11 respiratory distressed, on the other hand it might not.  
 12 So I think it can be very, very difficult for an  
 13 individual responding to an incident to say that's what  
 14 is going on. The way we taught it within the military  
 15 was: when you are thinking about proximity of an  
 16 explosion and you're looking at other injuries, there  
 17 are some injuries you may need to assume by virtue of  
 18 the other injuries you've got, and then exclude them  
 19 subsequently with your investigation.  
 20 Q. Thank you very much. That's all I wanted to ask you  
 21 about the management of blast injuries.  
 22 Is there anything else you feel it's important for  
 23 us to bear in mind, whilst recognising that you are  
 24 returning to give evidence in due course?  
 25 COLONEL MAHONEY: I think the key thing is to say that the

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1 important thing is basic, simple things done well.  
 2 That's what saves people in incidents. It's good  
 3 haemorrhage control, good airway management, it's  
 4 recognition of holes in the chest and managing those  
 5 appropriately. Good, basic first aid done well is what  
 6 is required.  
 7 Q. That is certainly a most helpful summary, thank you.  
 8 Colonel, I'm going to turn from you now --  
 9 SIR JOHN SAUNDERS: Before you do that, you'll be aware that  
 10 we have heard evidence of Brigadier Hodgetts' app.  
 11 COLONEL MAHONEY: Yes, sir, I'm a co-founder.  
 12 SIR JOHN SAUNDERS: Okay. Clearly, we are considering, and  
 13 will consider, making recommendations relating to that  
 14 because the public are the people who are on the scene,  
 15 often first, and have the first opportunity to do  
 16 something to help. Other people have suggested during  
 17 the hearing that there is still some controversy about  
 18 the use of tourniquets and how they should be used.  
 19 I would be helped in due course -- not now, but in  
 20 writing at some stage from you -- to know whether there  
 21 is that controversy and to what it relates. I do not  
 22 want to be in a position of making a recommendation  
 23 which may be controversial and where there is still some  
 24 investigation that needs to be done. So would you be  
 25 good enough to do that for me?

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1 COLONEL MAHONEY: Certainly, sir. I think we've addressed  
2 some of this in our subsequent reports as well, but we'd  
3 be very, very pleased to do that.

4 SIR JOHN SAUNDERS: Thank you very much.

5 MR GREANEY: Thank you very much.

6 I did say at the outset that we wouldn't be dealing  
7 with the arena attack and I repeat that we are not going  
8 to be dealing with any individual, but I believe it will  
9 help to provide context for what we're going to hear in  
10 chapter 12 if, first of all, professor you explain the  
11 methodology that was adopted by the panel and then  
12 if we turn to the colonel for an explanation of the  
13 classification of the general type of injuries that you  
14 applied in this case. Does that make sense as an  
15 approach?

16 PROFESSOR BULL: Yes.

17 Q. Could I ask you then to help us with the methodology  
18 that was adopted?

19 PROFESSOR BULL: Yes. I don't know if this is unusual, but  
20 this is what we were instructed and we were pleased to  
21 follow. So we met as a panel, all five of us, for  
22 a number of review meetings. We took a very considered  
23 approach to this where we first considered the  
24 post-mortem photographs. We then went through the  
25 post-mortem medical imaging together, and the medical

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1 imaging was the CT scanning, and of course this allows  
2 the three dimensional visualisation of anatomical  
3 structures relevant to secondary blast injuries in  
4 particular, but also other things, and of course imaging  
5 of the secondary blast fragments.

6 We also conducted formal injury scoring. This is  
7 an important part of what we did because it allows us to  
8 compare to the literature and to other incident data  
9 that is known and out in the open literature.

10 Q. So it sounds like a very cold thing to do, applying  
11 a scoring to injuries, but this was something that you  
12 regarded it as critical to do so that you could compare  
13 and possibly contrast what was in the data within the  
14 literature?

15 PROFESSOR BULL: That's correct. I could go into greater  
16 detail, but I will very briefly say what that scoring  
17 is.

18 Q. Yes, please.

19 PROFESSOR BULL: The injuries are scored -- each individual  
20 injury is noted, it's recorded, it is given a score,  
21 a value, a numerical value of 1 to 6, with increasing  
22 severity. And then, according to the literature, these  
23 are then summed in some way to give us an idea of  
24 survivability. So for example, there may be one injury  
25 score of 4 of one part of the body, and the literature

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1 might tell us that that would result in a chance of  
2 survival of 80%, perhaps.

3 Of course, that is a statistical approach and  
4 typically, when we are comparing with the literature,  
5 we have to compare with individual injuries rather than  
6 injuries where there have been -- blast injuries where  
7 there have been many, many injuries together. That  
8 makes this work quite difficult and I think we will end  
9 up discussing that in detail later on.

10 Q. I'm sure we will.

11 PROFESSOR BULL: But it was necessary to do so at this  
12 point.

13 We then --

14 SIR JOHN SAUNDERS: Is the scoring standard within the  
15 literature?

16 PROFESSOR BULL: It's not only standard, but those doing the  
17 scoring have to be accredited. I think it's worth  
18 noting that not all of the publications that include  
19 such scoring have accredited scorers who conducted that,  
20 so we have to go into the detail of these things  
21 sometimes.

22 MR GREANEY: The scoring that you undertook, as I've  
23 understood it, involved using something called  
24 the Association for the Advancement of Automotive  
25 Medicine Abbreviated Injury Scale or the AIS?

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1 PROFESSOR BULL: That's correct.

2 Q. Which is an internationally recognised trauma severity  
3 scoring system?

4 PROFESSOR BULL: Yes. Very importantly, it doesn't look at  
5 and it does not score physiology, the responses that  
6 Colonel Peter was just referring to, it is about  
7 anatomical injury.

8 Q. And I think we shouldn't be distracted by the fact that  
9 it's an Association for the Advancement of Automotive  
10 Medicine that designed this scoring system in the first  
11 place, it applies to all trauma?

12 PROFESSOR BULL: There are many scoring systems, but the  
13 only one that is recognised internationally and widely  
14 is this one.

15 Q. So I just want to be clear about one thing -- again,  
16 we're not looking at individuals, but when you did look  
17 at individuals and the issue of survivability, did you  
18 simply look at the score and make your conclusion or was  
19 the exercise more sophisticated than that?

20 PROFESSOR BULL: Far more sophisticated and I will go  
21 through what we did beyond this point, which I think is  
22 important.

23 Q. Yes. I think it is too, so carry on.

24 PROFESSOR BULL: Following the injury scoring, we created  
25 injury maps. So these were schematics on which we

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1 documented each one of the injuries. This was important  
2 for us as we then had to understand and analyse all the  
3 information we'd received prior to that, the post-mortem  
4 photographs and the CT scans, but also the information  
5 that we then looked at after that.

6 And at this point, I think it is safe to say that we  
7 took a pause and that we were able to identify  
8 individuals who had unsurvivable injuries, as we have  
9 previously discussed here today, at that point and we  
10 didn't need to go any further with any further detailed  
11 analysis for those for whom there was no doubt. And  
12 that was not everyone.

13 I think it's also worth noting that our approach was  
14 to be conservative, where we define conservative as  
15 erring on the side of survivability in all our  
16 assessments. We felt this was important as we were  
17 conducting not a statistical approach but a forensic  
18 approach for each individual. And we challenged one  
19 another and we challenged opinion as we went through  
20 this process.

21 But then we moved on, because clearly there were  
22 individuals for whom this was not definitive, and we  
23 reviewed witness statements and we -- even for all  
24 fatalities we reviewed witness statements to see if  
25 there were any inconsistencies and then we sought to

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1 reconcile those.

2 When the videos became available, we reviewed all of  
3 these and we followed up at that point with additional  
4 work, where questions were arising from that video  
5 footage and from the witness statements.

6 The additional work included conducting full  
7 three-dimensional reconstructions of the medical imaging  
8 and conducting an analysis of that; comparing each one  
9 of those individuals that we were considering to the  
10 most equivalent blast injury survival data available --  
11 and that is new information, and I will very briefly  
12 explain that here and we may refer to it later on.

13 So the military have a database, it is called JTTR,  
14 where they document all of the injuries and all of the  
15 fatalities and injury scoring can be conducted on those.  
16 So we have this wealth of data that allows us to  
17 investigate if there are individuals who have a similar  
18 or same injury constellation as those from the  
19 Manchester Arena bombing. And we're able to compare  
20 survivability of the cohort from the database with the  
21 individuals that we were considering and we did that.

22 Q. So people in that data who have the same or a similar  
23 injury profile to one of those who died in the arena  
24 attack?

25 PROFESSOR BULL: That's correct. And if we discuss those as

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1 individuals, we would then have to say how fidelic  
2 comparison that was, because of course it is very  
3 difficult to find those with exactly the same injury  
4 constellation.

5 Q. Indeed, the same injury constellation may not  
6 necessarily be determinative: one may have to have  
7 regard, for example, to how fit and healthy the  
8 particular individual was as compared with the person  
9 one is analysing?

10 PROFESSOR BULL: And not just fit and healthy. It's  
11 something that has not yet been mentioned, but clearly  
12 there are differences in physiological response and  
13 there's difference in anatomy between those who are  
14 young and those who are older.

15 Q. Absolutely, which is something we will get to but not  
16 today.

17 SIR JOHN SAUNDERS: Is that an international or national  
18 database?

19 PROFESSOR BULL: It is ours. There are equivalent  
20 databases -- the US have equivalent databases.

21 MR GREANEY: When you say ours, you're talking about the  
22 centre?

23 PROFESSOR BULL: No, UK military.

24 Q. Is there anything else that it is important that we  
25 should understand about the methodology that the panel

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1 adopted?

2 PROFESSOR BULL: Just one additional piece of work that was  
3 conducted where relevant was analysis of the  
4 physiological aspects and that was analysis of the blast  
5 injury modelling work that was conducted at DSTL and we  
6 incorporated that where necessary for individuals.

7 Q. Thank you very much.

8 As you'll appreciate, it was important that we  
9 should understand your methodology because it was the  
10 methodology that was applied to each of the 22 victims  
11 of the arena attack. There will come a stage when you  
12 return later, when it will be necessary for me, and  
13 I have no doubt others, to explore some aspects of your  
14 methodology in relation to at least one of those 22.  
15 I just say that so that everyone should understand that  
16 we'll need it look at this again in due course, as  
17 you'll appreciate.

18 SIR JOHN SAUNDERS: I don't want to consider it, but has  
19 this exercise ever been carried out before in these  
20 ways, these terms?

21 PROFESSOR BULL: Similarly, but not necessarily exactly the  
22 same. So for the Birmingham pub bombing, we conducted  
23 a very similar analysis, but we didn't have all the same  
24 information.

25 SIR JOHN SAUNDERS: This is something you did recently

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1 presumably?

2 PROFESSOR BULL: We did it for the inquests.

3 SIR JOHN SAUNDERS: So a long time after the event?

4 PROFESSOR BULL: That's correct.

5 SIR JOHN SAUNDERS: Does that matter? You don't need to

6 answer that in detail, but does it make a difference?

7 PROFESSOR BULL: If the records are available, it doesn't

8 matter, but some records were not available so we were

9 not able to do some of the things that we were able to

10 do now. And of course the medical training may well

11 have been different at that time. So we're also then

12 referring to Colonel Peter's evidence and how the

13 medical interventions may have been different.

14 SIR JOHN SAUNDERS: Thank you.

15 MR GREANEY: Was this kind of work also undertaken

16 in relation to the 7/7 attacks?

17 PROFESSOR BULL: That's also correct, but certain

18 information wasn't available. I wasn't involved

19 in that, Colonel Peter was, but I was involved in the

20 Birmingham one. For example, post-mortem CTs were not

21 available in that --

22 SIR JOHN SAUNDERS: Because of the length of time. But for

23 7/7, exactly the same procedure was gone through?

24 COLONEL MAHONEY: Very similar, sir. In 7/7, there was very

25 different availability of imaging, we didn't have the CT

1 post-mortem imaging, and there was very limited

2 photography on the victims. So we had to do, with the

3 aid of Porton Down, environmental modelling, looking at

4 the blast environments at a millisecond by millisecond

5 within the carriages and within the bus. So a similar

6 approach, but the nature of the incident and the nature

7 of available information meant that we had to finesse

8 our approach.

9 SIR JOHN SAUNDERS: Thank you.

10 MR GREANEY: Have I understood correctly, you were in

11 a better position in this case than you were in relation

12 to 7/7 to reach your conclusions?

13 COLONEL MAHONEY: Yes, that's correct.

14 Q. And were you in the same or a better position as

15 compared with Birmingham?

16 PROFESSOR BULL: Yes.

17 COLONEL MAHONEY: Far better.

18 Q. Professor, is there anything else it's important that we

19 should know about methodology, bearing in mind we're

20 just receiving your general evidence at this stage, or

21 can I turn to the colonel to help us with the definition

22 of certain terms?

23 PROFESSOR BULL: Nothing further.

24 SIR JOHN SAUNDERS: Can we be reminded of when Birmingham

25 was? I was in the city at the time.

1 MR GREANEY: 1974, sir.

2 The terms, colonel, that I'm going to ask you to

3 help us are important terms because they are the terms

4 that you use to define what had happened to the 22 in

5 this case.

6 COLONEL MAHONEY: That's correct.

7 Q. The first term I'm going to ask you to help us to

8 understand is unsurvivable. I'm at page 20 of your

9 report.

10 COLONEL MAHONEY: We were aware from the open access reports

11 in the media that a lot of people had survived the

12 bombing and so taking the approach that Professor Bull

13 has described, we wanted to be objective but we were

14 also trying to find reasons and asking ourselves: could

15 this person have survived? Is there something that

16 could have been done differently to allow this person to

17 survive? Is there something we would advocate which

18 would allow this individual to survive? So we were

19 going in very much thinking and looking for reasons for

20 individuals to survive.

21 We had a number of terms to classify the injuries

22 and one of the terms was "unsurvivable". Taking the

23 approach where we were saying, is there a reason for

24 this person to survive, if we said that we believed

25 somebody had unsurvivable injuries, it meant that we

1 felt the injuries were so severe that even if the most

2 comprehensive and advanced medical treatment was

3 initiated immediately after injury, we believe that

4 survival was impossible.

5 Q. Were you making that judgement by reference to the most

6 comprehensive and advanced medical treatment that was

7 available as of 22 May 2017?

8 COLONEL MAHONEY: Yes.

9 Q. The next term that you used is "unlikely to be

10 survivable"; what should we understand that to mean?

11 COLONEL MAHONEY: These are individuals whose injuries were

12 so severe that even if that same advanced and

13 comprehensive medical treatment was initiated

14 immediately after injury, we would not expect that

15 person to survive, but at that point we could not say

16 survival was impossible.

17 Q. The final term "potentially survivable".

18 COLONEL MAHONEY: This is where individuals had suffered

19 injuries that could prove fatal, but we had personal

20 experience of looking after casualties who had survived

21 such injuries. So survival was not guaranteed but we

22 believed that survival was -- we were certainly aware of

23 individuals who had survived such injuries with

24 appropriate treatment.

25 SIR JOHN SAUNDERS: That had to be the personal experience

1 of one of you?  
 2 COLONEL MAHONEY: It could be, sir, yes.  
 3 SIR JOHN SAUNDERS: Could be, but did it have to be? For  
 4 example, if there are examples of people in the  
 5 literature --  
 6 COLONEL MAHONEY: In the literature, personal experience,  
 7 our collective military experience, the JTTR as an  
 8 example.  
 9 SIR JOHN SAUNDERS: I just wanted to understand what you  
 10 meant by, "We had experience of people surviving".  
 11 COLONEL MAHONEY: We had experience both personally and  
 12 institutionally. What we didn't want to do was be  
 13 guided by anecdote, but if an individual said, "Hang on,  
 14 stop, I have managed this injury in this environment",  
 15 then we'd say, "Okay we need to pressure test that and  
 16 understand why you believe that", and then reach back  
 17 into the literature and make sure we had the appropriate  
 18 evidence to defend that.  
 19 SIR JOHN SAUNDERS: Thank you.  
 20 MR GREANEY: So Brigadier Hodgetts, have you had a chance to  
 21 see or to at least read the transcript of the evidence  
 22 of Brigadier Hodgetts?  
 23 COLONEL MAHONEY: Yes.  
 24 Q. He describes a group that was well recognised and  
 25 I think he called them unexpected survivors.

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1 COLONEL MAHONEY: He did, yes.  
 2 Q. Is that the sort of material that you had regard to so  
 3 long as it was more than merely anecdotal?  
 4 COLONEL MAHONEY: Yes, that was part of it. In addition we  
 5 had JTTR, the Joint Trauma Registry Records, that we  
 6 could reach into and we had the open access literature,  
 7 and we had our own experiences as well.  
 8 Q. I have said it many times but I know this is an issue  
 9 that we will need to come back to in due course.  
 10 Before I conclude my questions and turn to others,  
 11 is there any other issue that relates to the topic  
 12 you've just been dealing with that we ought to know  
 13 about, for example the difference in terms of  
 14 survivability that you have encountered as between blast  
 15 injuries compared with other forms of trauma?  
 16 COLONEL MAHONEY: I think what's key to say at this stage is  
 17 just how severe injuries from explosions are and can be.  
 18 Certainly when I was actively doing pre-hospital care,  
 19 I'd regularly attend road accidents and regularly attend  
 20 industrial accidents. You can have a very unpleasant  
 21 and very mutilating road accident, and I'm not in any  
 22 way dismissing that, but the sheer ferocity of an  
 23 explosion and the complexity of the injuries that you  
 24 can get from an explosion are almost in a different  
 25 league of their own. A league of their own.

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1 SIR JOHN SAUNDERS: I'm not quite sure whether this is  
 2 a sensible question or not, so if it's not, please don't  
 3 answer it. When you're describing how you approach  
 4 survivability, obviously from the point of view of the  
 5 lessons that can be learned from what happened at  
 6 Manchester, a conservative view, ie you err on the side  
 7 of survivability and what can be done is helpful from  
 8 the point off view of trying to think: was there  
 9 anything at all which could have been done which we can  
 10 learn from in the future?  
 11 COLONEL MAHONEY: Yes.  
 12 SIR JOHN SAUNDERS: That's one way of looking at it. On the  
 13 other hand, you can look at it and say, well,  
 14 if we decide they were survivable, that means we may be  
 15 saying that someone could have done something which they  
 16 didn't do, which is obviously something which one is not  
 17 keen to do necessarily. Do either of those two play in  
 18 and if you think that question is not helpful, then  
 19 please don't answer it.  
 20 COLONEL MAHONEY: Sir, I think it's an entirely fair  
 21 question. We were very conscious of what the inquiry  
 22 was asking us to do, that our brief was to look at  
 23 survivability, and by definition if you're looking at  
 24 survivability, you have to ask uncomfortable questions  
 25 and say, "Had this action been taken, would the outcome

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1 have been different", or, "If this action hadn't been  
 2 taken, would the outcome have been different?"  
 3 And again, we felt we owe that to the inquiry as our  
 4 duty to be able to give an answer for those  
 5 uncomfortable questions, and I suspect we'll be  
 6 addressing those when we look at individuals.  
 7 SIR JOHN SAUNDERS: Thank you.  
 8 MR GREANEY: It most certainly was not, if it's for me to  
 9 say, anything but a sensible question. I know that is  
 10 an issue that Mr Weatherby is concerned to explore,  
 11 although I doubt today. Can I say that I am satisfied  
 12 that once we have looked at the individual cases,  
 13 we will know where on that spectrum we are.  
 14 SIR JOHN SAUNDERS: Thank you very much.  
 15 MR GREANEY: So the two of you, if I may say so, are very  
 16 experienced experts, including at giving evidence.  
 17 Bearing in mind that what I'm seeking from you at this  
 18 stage is your overview evidence, is there anything else  
 19 that either of you consider that we need to be informed  
 20 about before we embark upon chapter 12?  
 21 PROFESSOR BULL: Not from me.  
 22 COLONEL MAHONEY: Not from me, no.  
 23 MR GREANEY: Sir, is there anything you would like to ask  
 24 before I ask Mr Weatherby in the first instance and then  
 25 Mr Cooper whether they have questions?

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1 SIR JOHN SAUNDERS: No, thank you.  
 2 MR GREANEY: Mr Weatherby, do you have any questions at this  
 3 stage, bearing in mind the witnesses will be returning?  
 4 MR WEATHERBY: Nothing at all at the moment, thank you very  
 5 much.  
 6 MR GREANEY: I know Mr Cooper does have a few questions.  
 7 Questions from MR COOPER  
 8 MR COOPER: I'll address you first if I can, Professor Bull.  
 9 As you know I represent a number of the families and I'm  
 10 aware that we're at the general phase at the moment of  
 11 questioning of both of you and we'll acutely adhere to  
 12 that.  
 13 You have spoken about fragments in your earlier  
 14 evidence — I address this to you, Professor Bull. My  
 15 question is this on a general basis: do nuts, for  
 16 instance, and other items like that, packed into  
 17 a device, as a primary fragment, react in a different  
 18 way to, say, simply bomb debris such as the packaging?  
 19 Do you understand what I'm getting at here?  
 20 PROFESSOR BULL: Yes.  
 21 Q. You've described the effect of the debris, the  
 22 packaging. We know that, generally, bombs can be packed  
 23 with dangerous items such as nuts. Do they react in  
 24 a different way after an explosion to general debris?  
 25 PROFESSOR BULL: There are multiple things going on. The

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1 first is how they are energised, and if they are very  
 2 close to the seat of the explosion, ie part of the  
 3 device, then they will be energised more and they will  
 4 receive more of the energy and therefore they will have  
 5 greater kinetic energy as they move. They will go  
 6 faster and they will tumble faster. If they are further  
 7 away, then of course they will have lower energy.  
 8 So typically that would be a way of understanding  
 9 the difference between primary and secondary fragments,  
 10 but not necessarily. So that would be on the continuum  
 11 there would generally be greater energy for those  
 12 materials/fragments that are packed as part of the  
 13 device.  
 14 Secondly, the shape and the mass is obviously — the  
 15 weight is obviously very important because the shape  
 16 itself can potentially be more detrimental, and the  
 17 aerodynamics of that shape will cause it to move through  
 18 the air in different ways.  
 19 So yes, they're absolutely critical and there is  
 20 much research that is being conducted on that, but  
 21 suffice to say that there is a difference between the  
 22 different types of fragments.  
 23 Q. Thank you.  
 24 SIR JOHN SAUNDERS: I think Mr Cooper's question was  
 25 predicated on — we're talking about either the

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1 packaging or the nuts and bolts inside. I don't think  
 2 we were talking about other things that can be swept up  
 3 as you describe.  
 4 PROFESSOR BULL: The packaging is extremely different,  
 5 clearly, in this case and other cases, from the nuts.  
 6 SIR JOHN SAUNDERS: Because of what they are made of?  
 7 PROFESSOR BULL: Because of what they're made of and  
 8 therefore the kinetic energy that they have — one items  
 9 will have a much lower mass, much lower weight and so it  
 10 will have much less energy.  
 11 SIR JOHN SAUNDERS: But could be sharper, for example?  
 12 PROFESSOR BULL: Yes.  
 13 MR COOPER: Is there a range that can be determined for  
 14 fragments that are affected by detonation, how far they  
 15 will travel? Is that determined, for instance,  
 16 logically on the force of the explosion or are there  
 17 other determinants as to how far these dangerous  
 18 materials travel?  
 19 SIR JOHN SAUNDERS: Can we be quite careful about not giving  
 20 information at this stage?  
 21 MR COOPER: Let me explain why I'm asking the question.  
 22 SIR JOHN SAUNDERS: You'll understand my concern.  
 23 MR COOPER: Absolutely. By explaining why I'm asking the  
 24 question, there may be a way round answering it.  
 25 Without going into the particularity of the evidence at

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1 this stage, some people closer to the detonation  
 2 received less injuries than those that were a distance  
 3 away from the explosion. And without going into the  
 4 particularity of the individuals, just asking about the  
 5 physics of it, how can it be perhaps — and I know this  
 6 is of concern to some members of families — that  
 7 someone closer perhaps to detonation receives less  
 8 injuries than someone further away from detonation?  
 9 PROFESSOR BULL: I'm glad to clarify this. First, the  
 10 explosive itself may not be a very consistent explosive.  
 11 It may detonate in a way that is not ideal. So what  
 12 that means, and that generally is not by design, these  
 13 things can just happen like that. So what would happen  
 14 is that the pressure and then the blast wind that  
 15 follows that pressure is not consistent around the  
 16 sphere. So what you would have is a sphere of pressure  
 17 and of blast wind coming, which has sort of peaks and  
 18 troughs, if one may explain it like that, and those  
 19 peaks and troughs would carry the debris or the  
 20 fragments in different directions with different energy.  
 21 That's the first point.  
 22 And that would provide one reason for why we saw  
 23 that. I think another reason is that, clearly, if there  
 24 are objects or individuals in the way, then clearly the  
 25 line of sight question would address that as well.

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1 I think, based on our expertise and on modelling that  
 2 has been done previously, nothing that we saw was  
 3 inconsistent with that.  
 4 Q. Thank you. On recommendations, we know the City Room is  
 5 not considered a closed environment, and therefore will  
 6 cause(?) an open environment. Are there any  
 7 recommendations either of you can think of that may  
 8 potentially protect to some degree people from  
 9 detonation? I'll start from an extreme example, whether  
 10 there should be partitions in open environments like  
 11 that, that may act as screens or protections to close  
 12 the environment? And might in the future open  
 13 environments like the City Room be designed in such  
 14 a way to restrict that openness and therefore to provide  
 15 a better degree of safety?  
 16 PROFESSOR BULL: We believe there are potential  
 17 recommendations, but I'm concerned about giving them in  
 18 this forum.  
 19 Q. Then please don't and I wouldn't ask you to here.  
 20 MR GREANEY: I think that we can say the work has been done  
 21 and continues to assist those responsible for buildings  
 22 in this regard. Is that fair way of putting it?  
 23 PROFESSOR BULL: That's correct.  
 24 MR GREANEY: I think we probably shouldn't go any further  
 25 than that.

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1 MR COOPER: I won't pry. Will the chair be made aware,  
 2 might I ask, of that work?  
 3 MR GREANEY: Yes.  
 4 MR COOPER: That's all I ask. Thank you.  
 5 May I move on to another matter, I think it's still  
 6 directed at you, Professor Bull, if I may, and this is  
 7 predicated on experiences that individuals had on this  
 8 tragic night. I ask it generally. Observations are  
 9 made about the noise of the explosion and the  
 10 detonation. Obviously, we can be bland and use lay  
 11 terms, "We think we know what an explosion sounds like",  
 12 but are there any nuances or particularities on how the  
 13 noise is produced from an explosion so as to perhaps  
 14 help those that heard it understand what was going on?  
 15 PROFESSOR BULL: I am unaware of detailed literature on  
 16 this, so I do not have specific knowledge and expertise  
 17 in that area and I don't know if it is available  
 18 anywhere. I apologise for that.  
 19 Q. Colonel, I don't know whether there's anything on that  
 20 basis you can add, but if there is no learning on it  
 21 I wouldn't press you unless there's anything you want to  
 22 contribute.  
 23 COLONEL MAHONEY: I don't think I can answer your question  
 24 the way you would like. Certainly, again, from personal  
 25 experience, it's really depended on the distance you've

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1 been to an explosion. Being in a room with one going on  
 2 outside, you get a shaking and a loud bang. For more  
 3 slightly more distant ones and you're outside, you might  
 4 get a flash, you might get a bit of a push, you probably  
 5 won't get as much noise if you're further away.  
 6 It really depends on the environment you're in and  
 7 whether it's a rocket, a car bomb, a person-borne bomb,  
 8 a mortar. It really depends on where you find yourself  
 9 and what's going on.  
 10 Q. Another of the experiences those we represent had  
 11 generally was the blinding flash, the momentary blinding  
 12 light, as it were, which caused debilitation. Again, is  
 13 there anything physically you can explain as to what was  
 14 going on there so at least this can be demystified for  
 15 those who experienced it?  
 16 PROFESSOR BULL: It's absolutely expected in such type of  
 17 explosions that you'd get a flash like that. It's  
 18 absolutely common and almost everyone will have  
 19 experienced that.  
 20 SIR JOHN SAUNDERS: And it is caused by?  
 21 PROFESSOR BULL: It's caused by the chemical reaction. You  
 22 get this flash — this extreme shock wave and extreme  
 23 burning that happens almost instantaneously, and  
 24 you have the shock wave going through the product as the  
 25 device is ignited.

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1 SIR JOHN SAUNDERS: Thank you.  
 2 MR COOPER: Again, finally on this topic, a number of people  
 3 experienced severe heat, some more than others, a severe  
 4 feeling of burning as far as they were concerned.  
 5 You have touched on it in your report. Is there  
 6 anything else either of you can add again as to the  
 7 physical mechanics of that as far as the bomb is  
 8 concerned, what's causing that?  
 9 PROFESSOR BULL: Whenever molecules move quickly, then heat  
 10 is produced, and there are lots of molecules moving very  
 11 quickly due to the pressure wave and the blast wind that  
 12 follows that — and of course there are actually things  
 13 that have been detonated, so there is fire present as  
 14 well.  
 15 Q. That's helpful. You understand the reason I'm asking  
 16 these questions on behalf of those we represent is  
 17 simply to demystify what went on, which for some might  
 18 be helpful.  
 19 PROFESSOR BULL: I'm very pleased to answer your questions.  
 20 Q. On another aspect, if I can deal with medical aspects —  
 21 and perhaps colonel, I should turn to you so far as  
 22 that's concerned.  
 23 You say at your paragraph 2.3.2 in your report that:  
 24 "Damage to blood vessels can cause early death but  
 25 there may be sufficient time for medical interventions

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1 to save life."

2 I'll be asking you other questions in due course on

3 this, there's no secret about it, I represent

4 John Atkinson and obviously at a later stage we will be

5 asking you some particular questions about the matter.

6 But I'm just talking about your general observation now,

7 which was touched upon by CTI:

8 "Damage to blood vessels can cause early death but

9 there may be sufficient time for medical interventions

10 to save life."

11 I presume from that you mean direct pressure, the

12 use of a tourniquet, and elevation, I think you said in

13 your evidence today?

14 COLONEL MAHONEY: Yes, if we're talking about an external

15 bleed, say with a limb injury, then all those factors,

16 pressure, elevation, tourniquet, may be appropriate and

17 may be required. But equally, you could have internal

18 damage to a blood vessel, internal damage to a big blood

19 vessel in the chest, and somebody could be bleeding out

20 very rapidly but you couldn't actually do anything about

21 it in the context of the incident because you can't see

22 it and you can't reach it, you're looking at surgical

23 intervention.

24 SIR JOHN SAUNDERS: So internal bleeding, you simply can't

25 do anything about?

1 COLONEL MAHONEY: Internal bleeding means you're looking at

2 surgery --

3 SIR JOHN SAUNDERS: Stemming the bleeding? If you know it's

4 occurring in a particular place internally.

5 COLONEL MAHONEY: If you can see something -- I will answer

6 the question, but if you can see something externally,

7 say bleeding from a limb that is coming out, you know to

8 put pressure, elevate and possibly a tourniquet. If

9 you have bleeding in the chest or the abdomen, then you

10 may know it's taking place, but short of actually

11 reaching in to stop it, you're fairly constrained.

12 SIR JOHN SAUNDERS: So external pressure will not stop

13 internal bleeding?

14 COLONEL MAHONEY: Certainly in something like a chest

15 injury, no, it won't. There is research and there has

16 been US military research looking at approaches to

17 abdominal bleeding, whether there are devices that could

18 provide external pressure to address bleeding within

19 particular parts of the abdomen. That's really fairly

20 new and innovative and it's not in -- certainly not in

21 routine pre-hospital care, sir.

22 SIR JOHN SAUNDERS: Thank you.

23 MR COOPER: You again, colonel, referred to this in your

24 evidence earlier on this morning, that certain injuries

25 are amenable to the application of a tourniquet.

1 COLONEL MAHONEY: Correct.

2 Q. You weren't asked as to what those injuries were, so let

3 me ask: what are these injuries that are amenable to the

4 application of a tourniquet?

5 COLONEL MAHONEY: So we're considering limb injuries and

6 limb injuries where you have -- where you're aware of

7 where the blood vessel is, aware of where the bone is,

8 and you can apply a tourniquet and effectively

9 pressurise a vessel against a bone and inhibit the flow.

10 It really depends on where you are in a limb. Does that

11 answer the question correctly for you?

12 Q. It does. It's a matter for the chair of course, but

13 certainly so far as I'm concerned.

14 Again on the subject of injuries concerning loss of

15 blood, it's a general question for now. In those sort

16 of injuries, is how someone is transported following

17 that injury a critical aspect to consider as well? By

18 that, I mean stretchers or otherwise.

19 COLONEL MAHONEY: So if we have a situation where bleeding

20 has been controlled by a tourniquet, for example, or

21 pressure or elevation, and you no longer have bleeding,

22 then the key consideration is getting them to

23 appropriate help, whether they were put on the stretcher

24 or maybe if they're stable enough, you might move them

25 in a chair or sometimes you might walk somebody out. It

1 really depends on their individual condition.

2 Where you have internal injuries, where you believe

3 there's still bleeding ongoing, you really want to

4 handle people very, very gently because you don't want

5 to do anything to make the bleeding worse. So under

6 those circumstances, if you have the ability to put

7 somebody on a stretcher and take them out in

8 a relatively controlled fashion, that's what you do.

9 But in threat environments, particularly in the military

10 environment, we frequently haven't had that luxury, so

11 we've had to accept a less-than-ideal evacuation to take

12 people out of direct threat and then try to address the

13 consequences subsequently.

14 Q. As you'll anticipate, I'll be returning to that topic in

15 a little more detail later, but that's all I ask for

16 now.

17 COLONEL MAHONEY: Sure, I understand.

18 Q. How important in terms of the injuries you've spoken of,

19 particularly blood loss injuries, how important is it to

20 maintain the consciousness of a victim?

21 COLONEL MAHONEY: I know people talk about it, but the key

22 thing is stopping the bleeding -- recognising the

23 injury, stopping the bleeding and getting them to care.

24 If someone's conscious, you hope they are maintaining

25 their airway and you hope that they are at least

1 demonstrating they're celebrating.  
 2 When I have looked after casualties, I haven't tried  
 3 to maintain their consciousness. If I've seen them  
 4 slipping into unconsciousness, I have taken that as an  
 5 indication of severity and something going on I would  
 6 like to deal with. I'm not trying to sound callous, but  
 7 I'm not that concerned about talking to them to maintain  
 8 their conscious level; I'm more concerned about what  
 9 is that decreasing conscious level telling me about  
 10 their ongoing injury.  
 11 Q. That's probably debunked a lot of myths we see in the  
 12 movies and such, where people are being kept awake and  
 13 talking, which seems to be an utter myth medically as  
 14 far as you're concerned.  
 15 COLONEL MAHONEY: Yes.  
 16 Q. Just one final topic now in terms of blast and ballistic  
 17 mechanisms. You say in your paragraph 5.10 --  
 18 SIR JOHN SAUNDERS: Sorry. You described it as a myth of  
 19 keeping people there and we all see this all the time of  
 20 people trying to keep people conscious to stop them  
 21 slipping away.  
 22 COLONEL MAHONEY: On television dramas, yes.  
 23 SIR JOHN SAUNDERS: If that is a misconception, is it a  
 24 misconception that should be rectified? Because it may  
 25 be that if you're trying to keep someone awake and

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1 conscious, you're not doing something else which you  
 2 might be doing. You would say you would be  
 3 concentrating on the bleeding rather than maybe keeping  
 4 someone conscious.  
 5 COLONEL MAHONEY: For me, it's more important to say why  
 6 am I seeing a change, so I need to be looking for  
 7 something rather than I need to be talking to this  
 8 person.  
 9 SIR JOHN SAUNDERS: Okay.  
 10 COLONEL MAHONEY: I'm not sure if I've answered that  
 11 correctly for you.  
 12 SIR JOHN SAUNDERS: You have. I understand what you're  
 13 saying. I was trying to conceive of whether -- if it's  
 14 certainly a misconception, it will be a misconception  
 15 that I and most people, I suspect, here would have,  
 16 whether it's a misconception which needs to be put  
 17 right.  
 18 COLONEL MAHONEY: Other people may disagree with me, but  
 19 certainly my approach --  
 20 SIR JOHN SAUNDERS: That's an important thing to know,  
 21 whether it is a matter for debate, as it were. Okay.  
 22 MR COOPER: Just this then, it's your paragraph 5.10 -- I'm  
 23 not sure whether this is for Professor Bull or you,  
 24 colonel, but either of you of course will pitch in:  
 25 "Blast and ballistic mechanisms are different due to

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1 the usual injury mechanisms encountered in UK civilian  
 2 NHS practice [as read]."  
 3 But is that really the case? I'm asking this  
 4 question as to whether domestic NHS practice should be  
 5 alert to these problems, for instance these explosions  
 6 can happen, for instance, as a result of a house fire or  
 7 a factory fire or indeed, very sadly, a number of health  
 8 and safety deaths. One only reads today of somebody  
 9 dying because of an explosive large beer keg that they  
 10 opened in the wrong way and the keg exploded. Should it  
 11 be that a civilian NHS practice should be far more alert  
 12 and far more informed and far more trained to deal with  
 13 those explosions, whether or not they're from a sinister  
 14 source?  
 15 COLONEL MAHONEY: If I could refer, please, to  
 16 paragraph 5.11, where we have described taking our  
 17 military experience and binding that into current NHS  
 18 protocols. I absolutely agree that you do get domestic  
 19 explosive events and industrial explosive events, which  
 20 present to hospital or present to the emergency services  
 21 and subsequently to hospital and are generally dealt  
 22 with extremely well by the NHS.  
 23 I think the key thing about the arena and other  
 24 terrorist events is that you are dealing with a device,  
 25 an event that has presented a complex constellation of

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1 injuries with frequently a significant number of  
 2 casualties and has invoked an understandable concern  
 3 about other likely threat. So you are managing  
 4 a significantly difficult environment, a number of  
 5 people, and you might be presenting individuals to  
 6 an NHS crew, an ambulance crew or a hospital who haven't  
 7 seen those injuries before.  
 8 This is the reason why the military were involved in  
 9 working with our NHS colleagues to develop the  
 10 guidelines discussed in 5.11. What these guidelines do  
 11 is give a very readily accessible means of seeing blast  
 12 injury, ballistic injury and blade injury so that if you  
 13 know you're on duty and people with these injuries are  
 14 coming to you in hospital, you can quickly refer to the  
 15 guidelines, understand what you're likely to face, and  
 16 indeed reassure yourself that most of your knowledge is  
 17 entirely applicable to managing that person.  
 18 Q. My last question following on from that: what's your  
 19 view on the adequacy and the level of consistent  
 20 training that is given to the NHS in relation to the  
 21 matters you have just referred to, that is military  
 22 perspectives upon the consequences of, for instance,  
 23 terrorist activity and bomb detonation? Is there an  
 24 increase in training that is necessary? Is all this  
 25 training going to the rank and file in the

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1 Ambulance Service or is it in a tiered way?  
 2 SIR JOHN SAUNDERS: Quite a big topic. If you don't feel  
 3 able to deal with it at this stage, by all means take  
 4 time to think about it.  
 5 COLONEL MAHONEY: It is a big topic and to have an  
 6 appropriate and accurate answer, you would perhaps need  
 7 to speak to individual NHS trusts and ambulance trusts  
 8 to understand what they're doing for their people. But  
 9 I think it's fair to say that there are some very  
 10 comprehensive courses that have been going for a number  
 11 of years addressing major incident management and  
 12 things, like in Birmingham, the trauma course about  
 13 teaching NHS people how to manage these types of  
 14 injuries has been running for a number of years.  
 15 There's plenty of training out there, but as to how  
 16 it's being addressed nationally, I'm the wrong person to  
 17 answer that.  
 18 MR COOPER: Was there training available pre-2017, do you  
 19 know?  
 20 COLONEL MAHONEY: The major incident management training,  
 21 MIMMS, also something developed by was Colonel, now  
 22 General Hodgetts, has been available for a number of  
 23 years and certainly pre-dated 2017. A number of the  
 24 courses have been refined since 2017. I think people  
 25 have definitely learned from the experience of the arena

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1 bombing.  
 2 MR COOPER: I'm grateful, sir, thank you. I have no further  
 3 questions.  
 4 SIR JOHN SAUNDERS: Thank you very much, Mr Cooper.  
 5 Further questions from MR GREANEY  
 6 MR GREANEY: Just one thing. The guidelines to which you  
 7 drew Mr Cooper's attention referred to a paragraph 5.11  
 8 of your report are dated 2018 is that correct?  
 9 COLONEL MAHONEY: That's correct.  
 10 Q. They post-date the arena attack?  
 11 COLONEL MAHONEY: They post-date the arena attack and the  
 12 requirement for them was influenced by the arena attack  
 13 and by the other attacks that took place in 2017.  
 14 Q. Which gives rise to the question of whether, as of  
 15 May 2017, that which had been learned on the  
 16 battlefields was sufficiently understood within civilian  
 17 NHS practice. Again, maybe a big topic.  
 18 COLONEL MAHONEY: I think it's a big topic and I don't think  
 19 it's correct for me to comment on. At the time I was  
 20 working in Birmingham in the Royal Centre for Defence  
 21 Medicine, where we were working hand-in-glove with our  
 22 civilian colleagues.  
 23 Q. I understand.  
 24 COLONEL MAHONEY: So if you take what Birmingham knew, where  
 25 we were constantly bringing this material back and

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1 looking after blast and ballistic casualties, both from  
 2 military environments and other environments, and I was  
 3 certainly very, very confident with how the Queen  
 4 Elizabeth Birmingham were managing such incidents, but  
 5 I cannot say what is happening in other trusts.  
 6 Q. So your experience within Birmingham may or may not have  
 7 been typical, you can't comment. But what you can say  
 8 is that, as we stand here today, the learning from the  
 9 battlefields is well understood within the NHS?  
 10 COLONEL MAHONEY: I think what we can say is that there is  
 11 certainly -- there's been attempts to provide that  
 12 learning with things such as the 2018 guidelines and  
 13 I believe there's a greater understanding within  
 14 ambulance services. Certainly when I've spoken to  
 15 ambulance crews, their understanding of blast and  
 16 ballistic injuries has been good and their understanding  
 17 of tourniquets has been good. How that permeates to  
 18 every ambulance trust or every hospital trust, I really  
 19 can't say.  
 20 SIR JOHN SAUNDERS: Birmingham is slightly different, isn't  
 21 it, because isn't that the centre where most people  
 22 injured abroad in the military are brought for further  
 23 treatment?  
 24 COLONEL MAHONEY: That's correct, which is why -- that's  
 25 where I was working up until early 2020 when I was still

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1 serving in the regular army. So my experience was based  
 2 around that, either on deployment or working back in  
 3 Birmingham. So it would be unfair of me to draw  
 4 conclusions from that because that's an unusual  
 5 environment.  
 6 SIR JOHN SAUNDERS: Thank you.  
 7 Further questions from MR COOPER  
 8 MR COOPER: Could you indulge me with one question. It may  
 9 or may not be a help.  
 10 SIR JOHN SAUNDERS: You can ask if it's going to be  
 11 a help, Mr Cooper.  
 12 MR COOPER: Is what you say of the provision of information  
 13 to the National Health Service -- do you have a similar  
 14 communication with the Fire Service?  
 15 COLONEL MAHONEY: Me as an individual, I don't.  
 16 Q. I don't mean you personally, I mean the general chain of  
 17 learning that you explained very helpfully that's  
 18 provided to the Ambulance Service, is there a similar  
 19 provision nationally to the Fire Service?  
 20 COLONEL MAHONEY: I really would need that question  
 21 addressed to the Fire Service. It is not something  
 22 I have personally been involved with.  
 23 SIR JOHN SAUNDERS: It's a sensible question and we will get  
 24 it answered. Thank you, Mr Cooper.  
 25 MR GREANEY: Sir, do you have any questions?

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1 SIR JOHN SAUNDERS: No, thank you.  
 2 MR GREANEY: That's taken a little longer than I expected.  
 3 I know that Ms Cartwright is very keen that she make her  
 4 remarks about process and procedure at this stage so  
 5 that the evidence is able to start at 1.30 sharp and  
 6 it's not interrupted. So could I suggest a break until  
 7 12.20, please?  
 8 SIR JOHN SAUNDERS: Thank you both very much. We'll be  
 9 seeing you again.  
 10 (12.12 pm)  
 11 (A short break)  
 12 (12.22 pm)  
 13 MS CARTWRIGHT: In the opening statement to the inquiry on  
 14 7 September 2020, Mr Paul Greaney Queen's Counsel  
 15 detailed that:  
 16 "In chapter 12 we will explore the experience of  
 17 each deceased victim. The cause of death of each person  
 18 will be investigated during this chapter and this  
 19 chapter will also provide an opportunity to remind  
 20 ourselves, and indeed the world at large, of the pen  
 21 portrait evidence heard in chapter 4.  
 22 "We should acknowledge that during and throughout  
 23 chapter 12 we will be dealing with matters that are  
 24 undoubtedly sensitive and likely to be distressing for  
 25 many, certainly the bereaved families and the witnesses

1 who will be called. As always, we will do what we can  
 2 to reduce the distress, although we recognise that  
 3 we can never be completely successful. However, we are  
 4 able to provide reassurance at the beginning of  
 5 chapter 12 that we will not be showing any CCTV or  
 6 body-worn video footage or still images.  
 7 "As is well-known, our inquiry process began as  
 8 22 inquests requiring findings as to how and in what  
 9 circumstances each of the 22 who died came by their  
 10 deaths and the medical cause of death. These aspects  
 11 are addressed by and respectful attention given to them  
 12 in the inquiry's terms of reference 6 and 7 and form the  
 13 focus of chapter 12."  
 14 Paragraphs 6 and 7 of the terms of reference  
 15 include:  
 16 "6. The experiences of each person who died,  
 17 including their travel to the arena, the locations they  
 18 visited, who they were with, their movements at and  
 19 around the arena."  
 20 And in paragraph 7:  
 21 "The immediate cause and mechanism of each death,  
 22 including:  
 23 "(i) The mechanism and cause of death;  
 24 "(ii) Exactly when and where each person died (to  
 25 the extent that this is possible to ascertain);

1 "(iii) Survivability, including whether any  
 2 inadequacies in the emergency response contributed to  
 3 individual deaths and/or whether any of the deaths could  
 4 have been prevented."  
 5 Turning next to preparations for chapter 12,  
 6 yesterday afternoon Mr Greaney Queen's Counsel detailed  
 7 that I would explain the process by which the chapter 12  
 8 evidence has been gathered and the procedure that will  
 9 be adopted during chapter 12 itself and an indication of  
 10 the intended timetable.  
 11 The inquiry legal team acknowledge in these  
 12 introductory remarks the extensive work that has been  
 13 undertaken for chapter 12 by Operation Manteline and the  
 14 team supervised by Detective Superintendent Theresa Lamb  
 15 and Detective Inspector Mike Russell. This has included  
 16 many hundreds of hours analysing the footage from  
 17 90 CCTV cameras, footage from 52 body-worn videos and  
 18 mobile phones, which has enabled to be extracted from  
 19 this evidence a clear timetable for each of those who  
 20 died and details: firstly, their arrival at the arena  
 21 for the concert; (2) the time when they entered the  
 22 City Room shortly before the bomb was detonated; (3)  
 23 their location in the City Room at the time of the  
 24 detonation; and finally, an analysis from after the  
 25 detonation at 22.31 and what happened to each of those

1 who died and the details of those who interacted with  
 2 and assisted them thereafter.  
 3 The work of the Operation Manteline team in  
 4 preparation for chapter 12 has been invaluable and the  
 5 inquiry legal team records and expresses its sincere  
 6 thanks to all of those in the Operation Manteline team  
 7 who have been involved in this sensitive and most  
 8 difficult work.  
 9 This work has resulted in 22 detailed, chronological  
 10 sequence of events for each of those who died, with  
 11 stills extracted from the CCTV body-worn video and,  
 12 where appropriate, mobile phone footage.  
 13 In addition to the 22 sequence of events for each of  
 14 those who died, a further 77 individual sequence of  
 15 events for witnesses have also been created by the  
 16 Manteline team. The focus of these sequence of events  
 17 has been the witnesses' interactions with each of those  
 18 who died.  
 19 Using the individual witnesses' sequence of events,  
 20 a comparison exercise has been undertaken of the witness  
 21 statements earlier provided to ensure any necessary  
 22 matters not addressed by the witness, when compared with  
 23 what is shown on the CCTV and body-worn video, was  
 24 addressed, with requests for additional statements being  
 25 made by the inquiry legal team.

1 Operation Manteline have interviewed and taken  
2 additional statements from approximately 45 witnesses in  
3 preparation for chapter 12. These additional witness  
4 statements will enable the questioning of the witnesses  
5 to be called in chapter 12 to be necessarily focused.

6 The inquiry legal team is grateful also to the  
7 Resilience Hub for its assistance in supporting  
8 witnesses with the statement-taking process and for the  
9 overarching support given and to be provided in  
10 chapter 12.

11 The work for chapter 12 has included the inquiry  
12 legal team preparing detailed evidence notes for each of  
13 those who died, which were provided to each of the  
14 representatives for the families. The purpose of those  
15 notes was to assist the families to understand all of  
16 the available evidence, about what happened to their  
17 loved ones, and to identify which parts of that evidence  
18 should fall to be adduced in evidence during the  
19 chapter 12 hearings. Those notes assisted the  
20 discussions with the family teams about what evidence  
21 should be heard, how, and from whom in chapter 12.

22 As can well be appreciated and understood, some  
23 families wished far less detail to be adduced in the  
24 final chapter 12 summaries of evidence; other families  
25 wished for more detail to be heard.

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1 The inquiry legal team is grateful to all of the  
2 families and their legal representatives for their  
3 cooperation with the process of preparations for  
4 chapter 12. As a result of these discussions, for 15 of  
5 those who died the evidence summary will be read as  
6 agreed with the family and no live witness evidence  
7 called. For seven of those who died, in addition to the  
8 reading of the evidence summary, live evidence will be  
9 called.

10 The evidence summaries to be read in chapter 12  
11 at the hearings each consist of, first, a reading of the  
12 summary of the pen portrait evidence that has been  
13 received in chapter 4, whilst a photograph of the person  
14 who died is displayed in the hearing room.

15 The families have chosen who should read this pen  
16 portrait summary. This will then be followed by  
17 a reading of a summary of the evidence that details the  
18 matters falling within the inquiry terms of reference 6  
19 and 7.

20 Detective Inspector Mike Russell will assist counsel  
21 to the inquiry with the reading of the summaries of  
22 evidence in chapter 12. Detective Inspector Russell  
23 will read the evidence as extracted from the evidence  
24 sequence of events prepared by his team. Rather than  
25 adducing this evidence in the format of questions and

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1 answers, Detective Inspector Russell will simply read  
2 those extracts from the sequence of events for each of  
3 those who died where the evidence appears in the  
4 summary.

5 The remainder of the evidence summary, from extracts  
6 of witness statements and other sources, will be read by  
7 counsel to the inquiry. This will include reading the  
8 medical cause of death as given by the pathologist  
9 following post-mortem examination, expressed using the  
10 formulation of medical causes of death used at inquests,  
11 namely 1A, the condition immediately causing death.

12 The summaries to be read, save for that of  
13 Saffie—Rose Roussos's will give a summary of the  
14 blast wave panel's conclusion on survivability and the  
15 conclusion of Dr Lumb and Professor Crane following  
16 their pathological review.

17 This afternoon, the summaries for Angelika and  
18 Marcin Klis and Courtney Boyle will be read.

19 Tomorrow, the summaries for Philip Tron, Olivia  
20 Campbell—Hardy, Michelle Kiss and Jane Twedde will be  
21 read.

22 On Thursday, the summaries for Lisa Lees,  
23 Alison Howe, Wendy Fawell and Nell Jones will be read.

24 On Monday, 27 September, the chapter 12 summary for  
25 Megan Hurley will be read as well as brief live evidence

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1 from five witnesses. In the afternoon of 27 September,  
2 the summaries for Eilidh MacLeod and Sorrell Leczkowski  
3 will be read.

4 On Tuesday, 28 September, the chapter 12 summary for  
5 Kelly Brewster will be read as well as brief live  
6 evidence from six witnesses. In the afternoon of  
7 28 September, the summaries for Liam Curry and  
8 Chloe Rutherford will be read.

9 On Wednesday of next week, the chapter 12 summary  
10 for Georgina Callander will be read as well as brief  
11 live evidence from nine witnesses.

12 On Thursday 30 September, the chapter 12 summary for  
13 Martyn Hett will be read as well as brief live evidence  
14 from witnesses. In the afternoon of 30 September, the  
15 summary for Elaine McIver will be read as well as brief  
16 live evidence from four witnesses.

17 In the week commencing 4 October 2021, the factual  
18 evidence for Saffie—Rose Roussos will be heard on 4 and  
19 5 October. The factual evidence for John Atkinson will  
20 be called on 6 and 7 October, and will continue on  
21 Monday 11 October.

22 As detailed by Mr Greaney yesterday when making his  
23 introductory remarks for chapters 11 and 12, he said  
24 this:

25 "The inquiry will consider the issue of

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1 survivability in the case of each of those who died.  
 2 This is, of course, an important question in its own  
 3 right and, moreover, will be capable of bearing on the  
 4 consequences of any failure in the adequacy and/or  
 5 effectiveness of the emergency response."

6 On 12 October, medical expert evidence will be  
 7 called to confirm the conclusions of the blast wave  
 8 experts and the pathologists, Drs Crane and Lumb, of all  
 9 of those who died save, for good reasons known to the  
 10 core participants, Saffie—Rose Roussos.

11 As there is an issue of survivability for both  
 12 Saffie—Rose Roussos and John Atkinson, the medical and  
 13 expert evidence will have to be examined in detail and  
 14 with care to enable you, the chairman, in due course to  
 15 determine the issue of survivability. This will take  
 16 place for John Atkinson by way of the evidence, the  
 17 medical evidence, on 12 October, and for Saffie—Rose  
 18 Roussos on 1 to 3 December of this year.

19 Sir, we will start the chapter 12 evidence summary  
 20 for Marcin and Angelika Klis at 1.30 this afternoon, and  
 21 could I ask that we adjourn now until that time.

22 SIR JOHN SAUNDERS: I am also very grateful for the work  
 23 that the police officers have done in assisting with  
 24 this process. I am also, as I said yesterday, grateful  
 25 to the core participants for the families for their

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1 assistance, but can I also say, Ms Cartwright, you have  
 2 taken the lead on this as far as the inquiry is  
 3 concerned and you have done an enormous amount of work,  
 4 along with other members of the team who have helped  
 5 you, and I'm very grateful for that.

6 I want to say one thing: when we had the pen  
 7 portraits as part of chapter 4, the importance of that  
 8 was to ensure that everyone was aware we were dealing  
 9 with 22 very individual and very special people.  
 10 Inevitably, since then, we have tended to deal with 22  
 11 all together, and it is good that we are being reminded  
 12 again that we are dealing very much with 22 individuals,  
 13 and I may say that I'm reminded of that every day as  
 14 I come into the hearing when I look at the portraits  
 15 which are behind me. But they have never been out of  
 16 our minds as 22 individuals, even though inevitably the  
 17 evidence was the same for all of them. Thank you.

18 MS CARTWRIGHT: Thank you, sir.

19 SIR JOHN SAUNDERS: 1.30.

20 (12.38 pm)

(The lunch adjournment)

22 (1.30 pm)

23 Evidence summary for ANGELIKA KLIS and MARCIN KLIS

24 MS CARTWRIGHT: Good afternoon, sir.

25 This is the chapter 12 evidence summary for Angelika

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1 and Marcin Klis. Please can their photograph be  
 2 displayed?

3 Please can Kim Harrison of Marcin and Angelika's  
 4 family's legal team now read the summary of pen portrait  
 5 evidence.

6 SIR JOHN SAUNDERS: Thank you.

7 MS HARRISON: Marcin and Angelika are the parents of  
 8 Aleksandra, Alex, and Patrycja Klis. They were both  
 9 born in Slawno in Poland and grew up in Darlowo in  
 10 Poland. Marcin was born on 21 October 1974 and Angelika  
 11 was born on 2 August 1977. Marcin was 42 at the time of  
 12 his death on 22 May 2017. Angelika was 39 at the time  
 13 of her death on 22 May 2017.

14 Marcin and Angelika were soulmates, they met in  
 15 Poland in the early 1990s and fell in love. They were  
 16 married in 1996. Alex was born in 1997, and Patrycja in  
 17 2003.

18 Marcin moved to England in 2004 and then Angelika  
 19 and their daughters joined him in 2007.

20 Marcin worked as a courier, then in Tesco, and for  
 21 the last 4 to 5 years of his life he was a taxi driver.

22 Angelika initially worked as a cleaner, then she  
 23 worked as a customer services assistant for Tesco. She  
 24 had held this job for 10 years.

25 Marcin liked photography and rock music. Angelika

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1 loved to watch films and to be in the sun. Their  
 2 daughters remember that:

3 "Their love for each other was incredibly strong,  
 4 they were so in love, as if they were teenagers without  
 5 a care in the world, but most of all they were happy,  
 6 they were soulmates, and they didn't want to be without  
 7 each other."

8 Marcin and Angelika were loved by their daughters,  
 9 who described them as their best friends and protectors.  
 10 Marcin and Angelika did everything they could to ensure  
 11 their daughters had everything they wanted and always  
 12 put their daughters' needs first. The family would  
 13 regularly go back to Poland as well as visiting other  
 14 countries such as Rome in Italy and Egypt.

15 Every few weeks, Marcin and Angelika planned a  
 16 family day as spending time with their daughters was  
 17 what made them happy. Alex and Patrycja describe their  
 18 parents as:

19 "Amazing parents, great friends and kind people."

20 SIR JOHN SAUNDERS: Thank you.

21 MS CARTWRIGHT: Marcin and Angelika had attended the arena  
 22 together with their daughters, Alex and Patrycja. Alex  
 23 and Patrycja went to the concert together and Marcin and  
 24 Angelika were to pick them up afterwards.

25 The family entered the arena through the stairwell

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1 that leads from the NCP car park to the arena, shortly  
2 after 18.30.

3 The family went to the City Room through the  
4 Trinity Way entrance, arriving at the City Room shortly  
5 before 18.45. Marcin and Angelika left the City Room at  
6 18.46 and walked into Victoria Station, before leaving  
7 the station through the exit leading to Station  
8 Approach.

9 Alex and Patrycja entered the arena from the  
10 City Room at 19.00 hours. Marcin and Angelika seemed to  
11 have a nice evening in Manchester and took photographs  
12 together.

13 DETECTIVE INSPECTOR RUSSELL: Marcin and Angelika returned  
14 to Victoria Station at 21.45. They entered the  
15 City Room at 22.23.40.

16 Marcin and Angelika stood in the City Room with  
17 their arms around each other at 22.28.56. They were  
18 standing towards the arena doors. They remained  
19 standing in this position until 22.30.59.

20 Marcin was approximately 5 metres away from the  
21 bomber at the time of detonation and Angelika was  
22 approximately 4 metres away from the bomber at the time  
23 of detonation.

24 Footage taken by a member of the public within the  
25 City Room is available approximately 34 seconds after

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1 detonation. Marcin and Angelika can be seen in some of  
2 this footage, which shows that, at 22.31.34, Marcin was  
3 lying on his side and appeared to be motionless.  
4 Angelika was lying next to Marcin on her side and did  
5 not appear to be moving.

6 CCTV shows Marcin and Angelika lying on the floor at  
7 22.31.58. Marcin and Angelika both appear to have been  
8 lying on their right-hand sides with their heads facing  
9 down towards the floor.

10 The sequence of events for Marcin at 22.32.18  
11 records that CCTV continued to capture Marcin at this  
12 time and that he had not been seen to move throughout  
13 the footage.

14 Travel Safe officer Philip Clegg entered the  
15 City Room just before 22.33. As he walked around the  
16 City Room his body-worn video shows that Marcin was  
17 lying on his side, motionless, at 22.36.10. Angelika  
18 was behind him.

19 At 22.38.02, CCTV captured Marcin and Angelika  
20 again. Both were lying on the floor and neither of them  
21 appeared to have moved position since they were last  
22 observed nearly 6 minutes before. Sarah Burke, a member  
23 of the public, leant over Angelika at this time. He  
24 moved away from Angelika at 22.38.04.

25 Footage then captures Marcin on several occasions,

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1 but he does not seem to move. Mr Clegg's body-worn  
2 video shows that at 22.42.59 Angelika was lying on the  
3 ground with ETUK arena medic Zak Warburton leaning over  
4 her.

5 At 22.43, Zak Warburton appeared to be assisting  
6 Angelika and remained with her until 22.43.22.

7 MS CARTWRIGHT: Mr Warburton has provided a statement dated  
8 5 July 2021. This statement was prepared following  
9 review of his sequence of events. In the statement,  
10 Mr Warburton confirms that he would have assisted  
11 Angelika but he does not recall any specific detail of  
12 his involvement with her.

13 He confirms that he would be checking for signs of  
14 life, such as breathing or a pulse, and that:

15 "Although the images show me doing so, I have no  
16 recollection of approaching Angelika, her injuries and  
17 whether she was conscious or not."

18 DETECTIVE INSPECTOR RUSSELL: At 22.44.30, ETUK first aider  
19 Ken O'Connor was stood over Angelika. At 22.45.02,  
20 Mr O'Connor placed a T-shirt over Angelika's body.

21 MS CARTWRIGHT: Mr O'Connor has provided a further  
22 statement. This statement had been prepared following a  
23 review of his sequence of events. In the statement, he  
24 confirms that his sequence of events shows that he  
25 covered Angelika. He does not specifically recall

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1 covering Angelika, though he does recall checking on  
2 a number of people who he believed to be deceased, and  
3 states that he could have covered Angelika out of  
4 respect and dignity for her.

5 DETECTIVE INSPECTOR RUSSELL: At 22.45.10, BTP Police  
6 Constable Jessica Bullough stood over Marcin.

7 MS CARTWRIGHT: PC Bullough has provided a statement dated  
8 21 July 2021 following a review of her sequence of  
9 events. BTP PC Bullough explains in the statement that  
10 she does not specifically recall any interaction with  
11 Marcin.

12 DETECTIVE INSPECTOR RUSSELL: By 22.50.22, Angelika's head  
13 and upper body had been covered by T-shirts.

14 At 22.50.46, BTP PC Stephen Corke was knelt near  
15 several casualties, including Marcin.

16 MS CARTWRIGHT: PC Corke has provided a statement dated  
17 22 July 2021, following a review of his sequence of  
18 events. He confirms in this statement that he checked  
19 Marcin's pulse at this time and that he could not detect  
20 one. He states that it was clear that Marcin had died  
21 at this time.

22 DETECTIVE INSPECTOR RUSSELL: By 22.53.15, Marcin's body had  
23 been covered with a poster. By 22.59.35, his head had  
24 been covered with a poster.

25 Marcin and Angelika are then seen on several

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1 occasions on the body—worn video of the officers that  
 2 were in the City Room. They both remained covered.  
 3 At 23.38.20, Police Sergeant John Whittaker was  
 4 sitting next to Marcin. At 23.38.25, Sergeant Whittaker  
 5 lifted the poster that was covering Marcin and appeared  
 6 to check his pulse.  
 7 MS CARTWRIGHT: PS John Whittaker has provided a witness  
 8 statement dated 29 July 2021 in which he clarifies:  
 9 "Having viewed images of [him] checking Marcin from  
 10 his sequence of events and [confirms] that the images at  
 11 23.38.05 and 23.38.41 are examples of me checking for  
 12 signs of life in the manner I have outlined, and again  
 13 I would have moved on upon not finding any sign of life.  
 14 I have no recollection of approaching and checking  
 15 Marcin."  
 16 DETECTIVE INSPECTOR RUSSELL: At 23.39.35, NWS paramedic  
 17 Patrick Ennis knelt down between Marcin and Angelika.  
 18 He turned first towards Angelika and then towards  
 19 Marcin.  
 20 At 23.39.40, Mr Ennis attached a label to Angelika  
 21 to identify her as deceased.  
 22 At 23.40.09, Mr Ennis appeared to be attaching  
 23 a label to Marcin.  
 24 MS CARTWRIGHT: Patrick Ennis has provided a witness  
 25 statement following review of his sequence of events.

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1 He confirms that he attached a label to Angelika to  
 2 identify her as deceased at 23.39.40 and that he  
 3 attached a label to Marcin to identify him as deceased  
 4 at 23.40.09.  
 5 I am next going to read a summary of the conclusions  
 6 of the medical evidence, which some may find distressing  
 7 and may wish to leave the room or turn off their feed.  
 8 The initial post—mortem for Marcin Klis. The  
 9 initial post—mortem for Marcin was carried out by  
 10 Dr Michael Parsons at Oldham Royal Hospital mortuary.  
 11 His post—mortem report is dated 25 September 2017.  
 12 Dr Parsons states that the distribution of Marcin's  
 13 injuries indicate that he was facing slightly towards  
 14 the origin of the explosion and that the overwhelming  
 15 majority of injuries were sustained to the left side of  
 16 his body.  
 17 Dr Parsons confirms that Marcin was declared dead  
 18 at the scene on 22 May 2017. Dr Parsons provides  
 19 a medical cause of death for Marcin as:  
 20 "1A, chest injuries."  
 21 The initial post—mortem for Angelika Klis. This was  
 22 carried out by Dr Charles Wilson at Oldham Royal  
 23 Hospital mortuary. Dr Wilson's post—mortem report is  
 24 dated 11 September 2017.  
 25 Dr Wilson identifies that the location of Angelika's

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1 injuries indicated that the blast from the explosion had  
 2 approached her from her left side. Dr Wilson provides  
 3 a medical cause of death as 1A, multiple injuries.  
 4 Turning then to the evidence of the blast wave  
 5 experts' panel. The blast wave experts' report is dated  
 6 27 September 2019. The report states that Marcin  
 7 sustained multiple secondary blast injuries with three  
 8 of particular significance. The written conclusions of  
 9 the blast wave experts are that Marcin's injuries were  
 10 unsurvivable with current, as at 2019, advanced medical  
 11 treatment.  
 12 The report also states that Angelika sustained  
 13 multiple secondary blast injuries, with two of  
 14 particular significance. The written conclusions of the  
 15 blast wave experts are that Angelika's injuries were  
 16 unsurvivable with current, as at 2019, advanced medical  
 17 treatment.  
 18 Turning then to the review by the forensic  
 19 pathologists, Dr Philip Lumb and Professor Jack Crane.  
 20 Dr Lumb and Professor Crane provided a report  
 21 in relation to Marcin Klis, dated October 2020. Dr Lumb  
 22 and Professor Crane state that death as a result of  
 23 multiple injuries would have been very rapid. Dr Lumb  
 24 and Professor Crane conclude that Marcin's injuries were  
 25 unsurvivable. This conclusion accords with the

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1 conclusion of the blast wave experts that Marcin's  
 2 injuries were unsurvivable with current advanced medical  
 3 treatment.  
 4 Turning then to Angelika Klis. Dr Lumb and  
 5 Professor Crane provided a report in relation to  
 6 Angelika Klis, dated 8 September 2020. Dr Lumb and  
 7 Professor Crane confirm that Angelika died at the scene  
 8 on 22 May 2017. Dr Lumb and Professor Crane state that  
 9 the epicentre of the explosion was just in front of  
 10 Angelika and Marcin. Dr Lumb and Professor Crane state  
 11 that unconsciousness would have been almost immediate  
 12 and death would have followed rapidly.  
 13 Dr Lumb and Professor Crane conclude that the head  
 14 injury was unsurvivable, even with prompt medical  
 15 attention at the scene. This conclusion accords with  
 16 the conclusion of the blast wave experts that Angelika's  
 17 injuries were unsurvivable with current advanced medical  
 18 treatment.  
 19 Sir, that concludes the evidence summary to be read  
 20 of Angelika and Marcin Klis. Could we reconvene at  
 21 3 pm?  
 22 SIR JOHN SAUNDERS: Thank you. Can I just say this. We  
 23 know that Marcin and Angelika had two daughters, Alex  
 24 and Patrycja. The night of 22 May 2017 was meant to be  
 25 a particularly happy occasion while they attended the

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1 concert. Instead, it turned into a complete tragedy for  
2 them, which no doubt has affected their lives hitherto  
3 and which they will never, ever forget.

4 But perhaps we were all struck by one passage in the  
5 tribute that they gave at an earlier stage, they  
6 remember that their parents' love for each other was  
7 incredibly strong:

8 "They were so in love, as if they were teenagers  
9 without a care in the world, but most of all they were  
10 happy. They were soulmates and they didn't want to be  
11 without each other."

12 MS CARTWRIGHT: Thank you, sir.

13 (1.51 pm)

(Adjournment)

15 (3.00 pm)

Evidence summary for COURTNEY BOYLE

17 MS CARTWRIGHT: Sir, good afternoon. This is the chapter 12  
18 evidence summary for Courtney Boyle.

19 Present in the hearing room is Courtney's mother,  
20 Deborah Hutchinson, Courtney's sister, Nicole Boyle, and  
21 Courtney's aunt, Andrea Hope. They are assisted today  
22 by their legal representatives and also present in court  
23 are the legal representatives for Robert Boyle,  
24 Courtney's father.

25 Please can the photographs of Courtney be displayed?

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1 Please could I ask Mr Duncan Atkinson Queen's  
2 Counsel to read the pen portrait summary of Courtney.

3 MR ATKINSON: Courtney was the daughter of  
4 Deborah Hutchinson and Robert Boyle and the sister of  
5 Nicole.

6 Courtney was born on 25 October 1997 in Gateshead.  
7 Courtney was 19 years old at the time of her death on  
8 22 May 2017.

9 The summary of the pen portrait evidence of  
10 Deborah Hutchinson.

11 Deborah, Courtney's mum, was besotted with her from  
12 the day she was born. She was a beautiful and happy  
13 baby and she grew up to be very close to her cousins,  
14 Amy and Ryan, and her little sister Nicole, who was born  
15 in 2002.

16 Courtney worked hard in school and she was  
17 determined to go to university to pursue her dreams.  
18 She developed a love of music and when she was 16 she  
19 got a part-time job to save up to go to Leeds Festival  
20 with her friends. It was there she met Callum, her  
21 boyfriend. Deborah recalls how lovely it was to see her  
22 daughter so happy and positive about her future.

23 Courtney achieved her dream of going to university  
24 in May of 2017. She had just finished her first year at  
25 Leeds Beckett University where she studied criminology

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1 with psychology. Courtney was loving life as a student.

2 She was the happiest Deborah had seen her. In

3 Deborah's words:

4 "Courtney had so much more confidence and my shy,  
5 quiet girl had become a gorgeous woman with a loving,  
6 caring nature to match."

7 Courtney achieved a first in the exams she had taken  
8 at the end of her first year at university and she was  
9 awarded an honorary degree from the university in July  
10 of 2017.

11 Deborah remembers her beautiful daughter:

12 "I know that as time goes by, my daughter's beauty  
13 will never fade, she will always remain beautiful."

14 A summary of the pen portrait from Nicole Boyle.

15 Nicole remembers that Courtney was someone that  
16 people would love to be around because of her witty and  
17 funny personality. Growing up with her was like growing  
18 up with a best friend. Nicole describes Courtney as  
19 a safe place for her, explaining how Courtney guided  
20 herself, Nicole and their mum through the darker times  
21 by, in Nicole's words:

22 "Shining light on these situations and ensuring we  
23 kept a smile on our face. Courtney was an amazingly  
24 bright and smart girl, who shone so bright in any place  
25 she was and still does today."

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1 Summary of the evidence from Andrea and Alan Hope.  
2 Andrea and Alan remember their gorgeous niece for whom  
3 they had a special place since the day she was born.  
4 Courtney was a massive part of their lives and they  
5 remember so many family fun days and telephone calls  
6 where the world was put to rights.

7 They remember Courtney as a beautiful and confident  
8 young lady who was loving and caring.

9 Summary of the pen portrait evidence from Amy and  
10 Ryan Hope.

11 Courtney was close to her cousins since she was  
12 born. For Amy, Courtney was her first best friend  
13 before Ryan and Nicole came along. When Ryan was born,  
14 Courtney became a little tomboy and she and Ryan would  
15 play with cars for ages. The cousins always had each  
16 other's backs and still do.

17 Finally, the summary of the pen portrait evidence  
18 from Callum Maundrill. He met Courtney at  
19 Leeds Festival when she walked into him by chance. They  
20 got chatting and the rest was history.

21 They had the best times of their lives together.  
22 For Callum, Courtney made the good times great and the  
23 bad times bearable. He spoke of Courtney's beautiful  
24 resilience that made her so strong and made her a pillar  
25 of stability and support for so many people, friends and

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1 family alike .  
 2 She and Callum loved each other to bits. In his  
 3 words:  
 4 "Seeing her blossom into the confident, passionate  
 5 free spirit that she was still to this day brings me  
 6 joy."  
 7 He described how he was so, so lucky to have bumped  
 8 into Courtney in that field at Leeds Festival.  
 9 Thank you.  
 10 SIR JOHN SAUNDERS: Thank you.  
 11 MS CARTWRIGHT: Courtney went to the arena with her sister  
 12 Nicole, mum Deborah, Deborah's partner Philip Tron, and  
 13 Philip's mum, June Tron.  
 14 Nicole was going to the Ariana Grande concert and  
 15 the others were taking her. Courtney had been picked up  
 16 from her student accommodation earlier that day and  
 17 Deborah remembers that they had lunch together and then  
 18 went holiday shopping.  
 19 Courtney was excited about an upcoming trip to  
 20 Amsterdam with her boyfriend, Callum. The group dropped  
 21 Nicole off at the City Room shortly after 18.00 hours.  
 22 Nicole had a VIP ticket and Courtney had queued with  
 23 her before Nicole went into the arena. Courtney kept in  
 24 touch with Nicole during the concert through texts. The  
 25 group then went for some food before returning to their

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1 car to wait to pick Nicole up. Deborah remembers that  
 2 she and Courtney were laughing together as they waited  
 3 in the car.  
 4 Courtney went with Philip to collect Nicole. They  
 5 entered Victoria Station at 22.20 and crossed the  
 6 footbridge leading to the City Room at 22.22.06.  
 7 DETECTIVE INSPECTOR RUSSELL: Courtney entered the City Room  
 8 at 22.22.11. After entering the City Room at 22.22.11,  
 9 she stood with Philip Tron near to the merchandise  
 10 stand. Courtney was approximately 4 metres away from  
 11 the bomber at the time of the detonation.  
 12 At 22.31.09, CCTV shows Courtney was lying on the  
 13 ground on her right—hand side. She was not moving. She  
 14 was in the same position at 22.32.07.  
 15 CCTV shows Courtney again at 22.38.02. She had not  
 16 moved position since she was last observed nearly  
 17 6 minutes beforehand.  
 18 At 22.38.18, a member of the public, Robert Grew,  
 19 leaned over Courtney.  
 20 MS CARTWRIGHT: Mr Grew has provided a witness statement  
 21 dated 13 July 2021, which was prepared following his  
 22 review of his sequence of events. In the statement,  
 23 Mr Grew confirms that he saw Courtney at 22.38.18 and  
 24 that at this time she was not moving or showing any  
 25 signs of life .

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1 DETECTIVE INSPECTOR RUSSELL: By 22.51.16, a white poster or  
 2 paper covering had been placed over Courtney's head.  
 3 From the video footage available, it has not been  
 4 possible to identify who covered Courtney.  
 5 At 23.38.26, NNAS paramedic Patrick Ennis approached  
 6 Courtney. At 23.38.55, he knelt next to her and placed  
 7 a label upon her in order to identify her as deceased.  
 8 MS CARTWRIGHT: Patrick Ennis has provided a witness  
 9 statement following a review of his sequence of events.  
 10 He confirms that he attached a label to Courtney at  
 11 23.38.55 in order to identify her deceased.  
 12 I am next going to read a very brief summary of the  
 13 conclusions of the medical evidence.  
 14 The initial post—mortem. Dr Wilson provides  
 15 a medical cause of death as 1A, multiple injuries .  
 16 Turning then to the report of the blast wave  
 17 experts. The written conclusions of the blast wave  
 18 experts are that Courtney's injuries were unsurvivable  
 19 with current, as at 2019, advanced medical treatment.  
 20 Finally, turning to the review by the forensic  
 21 pathologists, Dr Philip Lumb and Professor Jack Crane.  
 22 Dr Lumb and Professor Crane conclude that Courtney's  
 23 injuries were unsurvivable.  
 24 Sir, that concludes the evidence summary to be read  
 25 for Courtney.

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1 SIR JOHN SAUNDERS: Thank you. Can I say thank you to the  
 2 family for attending. Courtney was talented,  
 3 hard—working and would have had a successful and  
 4 fulfilling life . As we have heard, after her death, the  
 5 news came through she had gained a first class honours  
 6 in her first year exams at university.  
 7 Ironically , she wanted to be a criminal  
 8 psychologist, a dream she would never realise. However  
 9 good she became as a criminal psychologist, I doubt she  
 10 would have been able to understand the cruel criminal  
 11 act that so tragically took her life .  
 12 MS CARTWRIGHT: Thank you, sir.  
 13 (3.12 pm)  
 14 (The inquiry adjourned until 9.30 am  
 15 on Wednesday, 22 September 2021)  
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1 I N D E X

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