



# AUTO+ MEDICAL

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## CIRCUIT CENTRES

Medical centres at top-level circuits have improved hugely over the last 30 years P22

## F1 MEDICAL CAR

A look at the important apparatus inside the medical car of world's top series P28

## MIKE CONWAY

The IndyCar and Formula E driver on his successful return from injury P32

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## DANGER, HIGH VOLTAGE

Electric racing requires a whole new set of safety and medical solutions

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The FIA Formula E Championship is ushering in a new era of electric motor sport. But with it comes a new set of responsibilities. Medical preparation and care will be more important than ever when dealing with electric-powered cars and their associated risks.

In this issue, we focus on the particular medical risks associated with the series. This includes an in-depth look at the specific provisions, risk prevention and training that is required to meet FIA standards and ensure a safe operating environment. Dr Phil Rayner, newly appointed Permanent Medical Delegate for the series, also speaks about his career in motor sport and his views on Formula E.

We received a fantastic response to our first issue of *AUTO+Medical* with numerous letters and emails received from the motor sport medical community around the world. We have published some of those letters in this issue. I would encourage you to continue submitting your thoughts and ideas for content as the journal is best served as a collaborative effort where knowledge can be shared. I hope you enjoy the second issue of *AUTO+Medical* and I look forward to receiving future contributions from across the globe.

**Professor Gérard Saillant**  
FIA Institute President

# LETTERS

*In this section, we print the best letters and emails received from readers around the world. We welcome comments on articles as well as suggestions for future content or insight into an area of motor sport medicine you feel would be relevant. If you wish to send in a letter or email, please direct it to: [medical@fiainstitute.com](mailto:medical@fiainstitute.com)*

Dear Editor,  
I would like to congratulate you on the first issue of Auto+ Medical, the international journal of motor sport medicine. It has been a very good read.  
I was wondering how often will the journal be published per year, what will be the 'Topic' of the next journal, and what is the last date of submission? I am interested in publishing some work for it.  
Many Thanks

Best Wishes  
DR SAKHAWAT ALI, ROCKINGHAM RACE COURSE

*Editor: AUTO+ Medical is published quarterly and we welcome contributions from doctors on any subject related to motor sport medicine. Our next issue will be published in November and we would require submissions by end of October.*

Dear Editor,  
Nice images along with good content. No glaring errors or omissions; a job well done.

DR. TERRY TRAMMELL, FIA INSTITUTE FELLOW

Dear Editor,  
It has shaped up very well, top stuff. The whole thing looks really good.

DR. MICHAEL HENDERSON, CHAIRMAN,  
AUSTRALIAN INSTITUTE FOR MOTOR SPORT SAFETY

Dear Editor,  
Felicitations, well done!

ARI VATANEN

Dear Editor  
An excellent publication that I hope will affect the health and safety at all levels of motor sport, as well as normal road driving.

MARY ZEITNER, WASHINGTON UNIVERSITY

Dear Editor,  
I felt that I should write and congratulate the Institute for creating Auto+ Medical, which is an excellent tool to communicate with the motor sports medical fraternity. Will you be including articles about extrication and disincarceration in future issues? If so then I should like to submit an article about research carried out by the BTCC Medical Team into the difficulties posed by polycarbonate windows.  
Many thanks

Best regards  
MARTIN HUNT, RESCUE CO-ORDINATOR,  
BRITISH AUTOMOBILE RACING CLUB

*Editor: Thanks. Each issue will have a main theme but we would also encourage submissions on any motor sport medical subject. An article on your research would be most welcome.*

Dear Editor  
I have just read the first issue of AUTO +Medical with great interest, thank you.  
I think this type of publication is always a benefit to us as Medical Professionals & providers of Motorsport Medicine & more importantly to the patients who we treat when things go wrong.  
Thank you for a wonderful publication & I look forward to issue 2.

Yours in Motorsport  
DAVE STUBBS, PARAMEDIC

Dear Editor,  
A friend has sent me a copy of the new Auto+ Medical journal. The gap in medical journal coverage is now filled!  
Please include me in the mailing list for future editions.  
Thank you!

DR. JOHN DAVIES FRCA (MSA, UK)

*Editor: Thanks you for your kind words. You are on the list!*

## STAR LETTER

Dear Editor

I was keen to write in to thank the FIA for the excellent work they are doing in evolving the field of motor sport medicine. The magnitude of the task, especially on an international scale, should not be underestimated.

One of the greatest challenges that faces clinicians in motor sport is the variation in guidelines on the management of the traumatically injured patient across the world. Even in individual regions there exists conflicting guidance from different professional bodies, which leads to confusion amongst clinicians and subsequently variability in treatment offered to patients.

This is of course not a unique problem to motor sport, or a unique problem in pre hospital emergency medicine. But in the comparatively small world of motor sport medicine, it is a much more tangible problem.

Examples of this include the sometimes thorny issue of cervical spine clearance following significant mechanism of injury. Multiple major international guidelines exist, yet applying one set will result in a very different treatment decision than that reached by applying another set in the same patient. Furthermore, there is little agreement on which guidelines should apply, as none were designed for use on the racing driver who has crashed a modern racing car, into an energy-absorbing wall, while wearing a range of protective devices. We know motor sport has become substantially safer in recent years, but we still don't really understand the individual contribution of each of these components in achieving this triumph.

Many of us, especially those more seasoned in our motor sport careers, probably learnt our craft from other experienced doctors. We make decisions based to an extent on guidelines, but also based on our experience. We fortunately work in a profession that values this experience greatly. However the world is, perhaps rightly, changing. There are constant calls for evidence to support our decision making in medicine, and this has rightly produced huge advances in medical care across all specialties. Yet it has also created its own problems. If evidence does not exist to answer the question with which we are faced, then critics will often look to other related evidence, from which they extrapolate conclusions.

The FIA is in a unique position, as an international body, to support the development of this evidence base, through research and development. This will serve to answer the questions, which challenge the frontline clinicians amongst us, and produce a more robust and defensible environment for training of future generations of motor sport doctors.

From watching Formula 1 as a young boy, I remember listening to beloved commentators talking about how developments in high level motor sport eventually filter down to make a better family car. This rings true for medicine too. What we learn about trauma and injury patterns in this most unique environment can only serve to further our knowledge of trauma in the wider sense, and will contribute to advances in care, both for our friends who trust us to do our best by them if they crash, but also for the wider population.

So I would applaud the FIA's work to date and hope it continues at pace. I would also ask all of your readers to support this work and spread the message to their colleagues. Motor sport medicine is unique, both in terms of the injury patterns we encounter, the speed at which we can attend our patients, and the level of detail we can obtain about injury mechanisms. We must not squander this opportunity to learn more about our craft, and must therefore support this research in any way we can.

Yours truly

DR JONATHAN WHELAN  
CONSULTANT IN ANAESTHESIA, INTENSIVE CARE, AND PRE HOSPITAL EMERGENCY MEDICINE  
WALES, UK

# GLOBAL NEWS



## TRAMMELL TARGETS WRIST INJURIES

FIA Institute fellow Dr Terry Trammell has been helping to develop greater hand and wrist protection in IndyCar accidents.

Trammell, who works as a safety consultant for the series, has explored a number of different options including a thumb/wrist brace or energy-absorbing material for steering wheels. It follows a spate of injuries to drivers following hard impacts.

Unlike other single-seater series, IndyCar uses aluminium steering arms as opposed to power steering. This means that all of the force from the front suspension can be transferred through to the steering wheel and the drivers' hands in the event of an accident.

Dr Trammell said: "The thumb is the most frequently injured part of the hand, and designing a brace that keeps the thumb at normal excursion but not any further has been a challenge."

Trammell has been working with a number of manufacturers to create a brace that affords adequate protection yet still retains ease of movement for the driver. A brace may also prove effective in accidents where the steering wheel strikes a drivers wrist following an impact with the wall.

A hydraulic damper has been suggested as a further solution and was recently tried out by driver James Hinchcliffe in an in-season test.

## DOCTOR WINS JIM CLARK AWARD

The UK Motor Sports Association's Dr John Harrington has become the first ever doctor to be awarded the prestigious Jim Clark Memorial Award. Chosen by the Association of Scottish Motoring Writers, Dr Harrington was recognised for his work in improving medical standards and provisions at rallies for almost 30 years.

Dr Harrington is an MSA international training instructor and helps to recruit new doctors and paramedics to the Scottish Motorsport Marshals Club.

Speaking after receiving the award, he said: "New medics benefit from our excellent emergency medicine courses and this helps them gain confidence outside of the hospital environment. For me, this kind of contribution and improving links between motor sport and the local emergency services has become a hobby and an extra-curricular interest. For it to be publicly recognised with the Association's Jim Clark Award is both a personal honour and a tribute to the skilled safety and rescue teams we have on Scottish rallies."

Dr Harrington first volunteered to work in motor sport in 1987 and went on to become Chief Medical Officer of the Highland Snowman Rally, a role he continues to occupy today. He is credited with improving the communication and preparation of both medical and recovery teams.

Alisdair Suttie, President of the Association of Scottish Motor Writers, said: "At a time when rally safety is in the spotlight, we were especially pleased to present this year's Jim Clark Memorial Award to a medically qualified winner. Dr Harrington demonstrates the planning and preparation that goes into motor sport events, the high levels of expertise available to competitors and the professionalism that swings into action when required."



## MEDICAL DELEGATES APPOINTED FOR FORMULA E

The FIA Commission, with the support of FIA President Jean Todt and Secretary General for Sport Jean-Louis Valentin, has appointed Dr Phil Rayner as the first Permanent Medical Delegate for the Formula E championship.

Dr Rayner, who is also the Chief Medical Officer for Wales Rally GB, has over 30 years experience in motor sport and is a member of the FIA Medical Commission. Dr Bruno Francheschini has been appointed as Deputy Medical Delegate for the series.

The FIA Formula E championship is a new global race series for all-electric single-seaters. It will take in ten races on city centre street circuits, beginning in Beijing in September.

### FORMULA E CALENDAR

13 September 2014	Beijing, China
22 November 2014	Putrajaya, Malaysia
13 December 2014	Punta del Este, Uruguay
10 January 2015	Buenos Aires, Argentina
14 February 2015	To Be Confirmed
14 March 2015	Miami, USA
4 April 2015	Long Beach, USA
9 May 2015	Monte Carlo, Monaco
30 May 2015	Berlin, Germany
27 June 2015	London, United Kingdom

## DR JOHN MELVIN, 1938-2014



Dr John Melvin, Fellow of the FIA Institute and Adjunct Professor of Biomedical Engineering at Wayne State University, made a huge contribution to driver safety both on the road and on the track. He conducted and published research on the biomechanics of impact injury and its application to the protection of vehicle occupants in crashes for over 45 years. His research on racing driver safety over the past 22 years made him one of the world's foremost authorities on crash protection.

Melvin's career started as a Research Engineer and Associate Professor at the University of Michigan Transportation Research Institute, from 1968 to 1985. He was involved in the planning and implementation of research projects dealing with the mechanical properties of biological tissues; injury mechanisms of the organs and structures in the head, neck, chest, abdomen, and lower extremities; development of test dummy components; and the development and evaluation of advanced restraint systems for children and adults.

From 1985 to 1998 he was a Senior Staff Research Engineer at the General Motors Research Laboratories where he conducted research on head and neck injury, and, most recently, racing car crashes for the purpose of improving both racing car and advanced passenger car crash protection. He retired from General Motors in September 1998 and became an independent consultant on the biomechanics of crash injury and racing car driver crash protection.

Melvin went on to serve as a consultant to many racing organizations such as CART, IRL, NASCAR and

the SFI Foundation, as well as the FIA Institute as a member of both the Open and Closed Cockpit Research Groups.

He was hugely admired and respected by his peers. Robert Hubbard, inventor of the HANS device, said: "John Melvin was the first person I went to for assurance that my concept for head support was sound - my approach to reducing head motions relative to the torso would be biomechanically correct. John's encyclopaedic knowledge of crash injury biomechanics, his sound practical judgement, and his masterful teaching has been the cornerstone of the revolution in racing safety."

Thomas Gideon, NASCAR Director of Safety, Research and Development, who worked with and succeeded John as Safety Manager at GM Racing, said: "John solved many problems that had existed for years in racing cars with respect to reinforced seats, head restraints, drivers' nets, and belt restraints. He took the time to report his findings and share with the racing community. He has been an indispensable part of the NASCAR Safety effort for over 13 years. John's legacy will be that he found solutions, and it is left to us to make sure that we get his message to those who have not learned."

Melvin laid the foundation stones of the science of motor sport safety, upon which the FIA and FIA Institute have been building for the last 20 years. His wisdom and deep experience will be sorely missed. No longer will it be possible to solve a problem of analysis or understanding by simply saying: "Ask John Melvin."



Dr John Melvin died unexpectedly on 17 July, aged 76.

## MEDICAL EXPERTISE DEMONSTRATED IN GERMANY

The Deutscher Motor Sport Bund (DMSB), Germany's National Sporting Authority, exhibited its medical expertise with a full-scale disaster response demonstration during the FIA Sport Conference in Munich.

At the event held in June, the DMSB set up an indoor scenario involving an explosion in a garage at a circuit. The scenario involved multiple casualties and a driver stuck in an unsafe Formula One car. The medical team from the DMSB then showed how to deal with such a scenario.

With limited space, and difficulty in accessing casualties, the scenario involved a number of different services and people including medical and disincarceration teams, marshals and firefighters. Chief Medical Officer Dr Michael Scholz said: "Our philosophy was not just to train the different services separately, but together."

All of the teams worked closely throughout the exercise, building key relationships and understanding, whilst maintaining constant communication via radio. Delegates at the sport conference were able to follow the demonstration via a live TV link and the scenario was then discussed with Dr Scholz and the various teams.

FIA Institute President Gerard Saillant said: "It is important that medical teams practice alongside the other essential rescue units that are on the scene following an accident. The DMSB has demonstrated the best practice in this area and sets an excellent example for others to follow."



## PAN-AMERICAN MEDICAL CONGRESS LAUNCHED



The inaugural FIA Pan-American Medical Congress will be held in Acapulco, Mexico on 12-14 November, in association with the Organizacion Mexicana del Deporte Automovilistico Internacional.

The three-day event will focus on safety and trauma interventions in motor sport. It will be the first FIA medical event to bring together knowledge and expertise from North, Central and South America.

It is hoped the Pan-American Congress will become an annual, cross-continental platform for medical professionals working in motor sport to share information and knowledge.

The congress will be focused on training both experienced and rookie motor sport doctors and medical staff. Presentations and discussions will focus on a variety of topics including practical extrication, major trauma car and road safety. Emerging issues in motor sport including electric and hybrid vehicle safety will also be discussed.

The FIA Institute will support the event by hosting a dedicated session on medical and safety issues at rally events. Chief Medical Officers Dr Jean Duby, Dr Manuel Alberro and Dr Michael Scholz will lead this presentation and discussion.

## MIDDLE EAST TO HOST MEDICINE IN MOTOR SPORT SUMMIT

The 2014 Medicine in Motor Sport Summit will be held in Doha, Qatar on 1-2 December. Forming part of the FIA General Assembly Week, the summit will bring together motor sport professionals to discuss a range of medical and safety topics.

Jointly hosted by the FIA and FIA Institute, the summit will include a dedicated day at the world-renowned Aspetar Hospital, the first specialised Orthopaedic and Sports Medicine Hospital in the Gulf. These state-of-the-art facilities will host a range of workshops, practical exercises and interactive discussions under the guidance of leading sports medicine practitioners.

The biennial FIA Chief Medical Officers' seminar will also feature at the summit and all Chief Medical Officers acting in an FIA World Championship will attend. A number of round table discussions are scheduled, with a particular focus on electric and hybrid car safety. Proposed topics for additional round table discussions include rally safety, closed car extrication and patient transfer.

In addition, keynote speeches from two leading experts in motor sport medicine will be given.

Medical Officers, leading sports medicine experts, motor sport physicians, the FIA Medical Commission members and the FIA Institute Medical Advisory panel, will attend the event.

Registration for the summit is now open.



## SINGAPORE TO HOST FIRST TRAINING EVENT

The Serious Accident Study Group (SASG) will hold its inaugural regional training event on 4-5 October in Singapore.

The two-day event will focus on rally safety and cover topics including organisation, emergency rescue and first on the scene response. Medical delegates from all 19 National Sporting Authorities (ASNs) in the Asia-Pacific region have been invited.

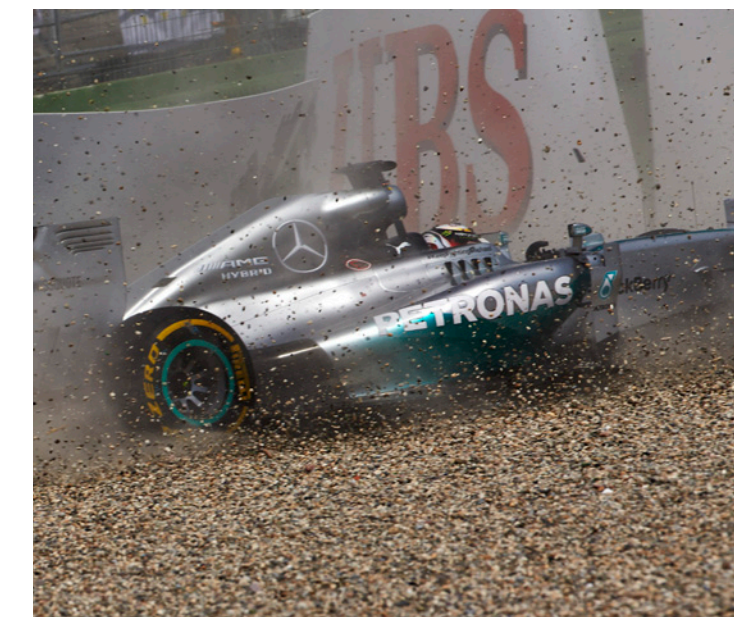
One of the key medical objectives of the SASG is to promote the highest standards of 'first-on-scene' and emergency response training. As part of this commitment to improve medical rescue skills, both internationally and across championships, the SASG will be conducting further regional-based training events over the next 12 months.

The first morning of the Singapore event will provide in-depth seminars on event planning. This will include advice on establishing disaster plans and effective working proto-

cols during a race. Emergency rescue will be covered in the afternoon with lectures discussing the theory of resuscitation, disincarceration and extrication. The final session will take place the next morning and will focus on first on scene response and first aid training.

Senior trainers and expert motor sport medical practitioners will lead the lectures and seminars. It is hoped that the President of each invited ASN's Medical Commission along with their internal Head of Medical Affairs will attend. Chief Medical Officers are also encouraged to attend.

The SASG was established by FIA President Jean Todt to collect data from accidents where life had been, or potentially was, threatened. The study group then evaluate the data and make recommendations to improve safety whilst working with global medical experts from other sports.



## WORLD ACCIDENT DATABASE BEGINS TEST PHASE

The FIA has launched the beta version of a World Accident Database that could help to hugely improve safety in motor sport.

A cross-section of National Sporting Authorities, including all accredited FIA Institute Regional Training Providers, have been invited to participate in the pilot project to test and develop the database. Over recent months they have been entering data from any fatalities and serious accidents that have occurred in their territory.

The information in the database can include video footage, photographs, ADR data, medical reports and technical reports from motor racing accidents. This will have a huge safety benefit for championships as the FIA can more accurately target research and develop activities. Furthermore, it will support more precise safety strategies for the FIA and its member clubs.

FIA Institute research consultant Andy Mellor said: "Accident data will be collected across all levels of the sport from Formula One to Club Racing and Karting. By analysing the data, we will determine and target those areas where the most significant and cost effective safety enhancements may be achieved, at both national and international levels. More focused R&D will support the next generation of improvements to vehicle, circuit and safety equipment design, to ensure the highest level of protection to our participants".

The database is set to launch fully in 2015.



# FEATURES

## DANGER, HIGH VOLTAGE

*The FIA Formula E Championship is bringing a new style of electric racing to motor sport. But with it comes a whole new set of issues, particularly in terms of safety and medical supervision.*

Building any new race series from scratch is an extremely challenging endeavour. To arrange and collate all the strands that make up a global championship takes immense drive, extreme commitment and plenty of patience. But to do that with the most powerful set of electric race cars ever built brings a whole new level of challenges.

The most important element of these is safety. A 200Kw battery, the equivalent of 270bhp, powers the all-electric Spark-Renault cars that every team in the championship uses. This means there is an ever-present danger of electric shocks and electrical fires.

This is why the FIA and Formula E have brought together a team of experts to ensure the strictest safety and medical procedures are adhered to by everyone in the championship. The operation is overseen by a working group led by FIA Head of Safety Jacques Berger, Formula E Technical Direc-

tor Carlos Nunes, MDD Europe Director Mark Lait and Dr Phil Rayner, who is the first Permanent Medical Delegate for the championship.

“The issues that we have to consider are potential risks from an electrical drive system,” said Dr Rayner. “We have looked closely at the Formula E system and although it is an extremely safe system with a huge amount of fail-safe engineering built in, we still have to think about the worst-case scenario.”

Series organisers have placed great importance on making their cars as safe as possible. Not only do they meet the most stringent crash-test standards but they include a number of features to prevent electric shocks and fires. But there is always the human factor and the only way to keep everyone safe is through education and training.

This is why every person involved, from team personnel through to marshals and



doctors, must take a safety training course before working in the championship.

MDD Europe developed this medical course in conjunction with the FIA and provides that training.

“This involves a high level of first aid training to deal with traumatic injuries. We do specific modules on the treatment of electric shocks and early defibrillation in relation to electric shocks,” says Mark Lait, Director of MDD, which also provides medical equipment and training in Formula One.

Other modules included fire safety training and pit lane evacuation. In other championships, one member from each team would receive training but Formula E is different. Lait explains: “The decision to educate all team members was the result of a discussion with the working group. First of all, there are four live cars in the garage at any time, which is double the number in Formula One. You have additional equipment in the garage such as battery

chargers so there is a significantly higher opportunity of an injury.”

The working group was keen to ensure that the medical course was thorough and covered every scenario. “We train each person to a standard that we call ‘first person on scene’,” says Lait. “That is the equivalent of ambulance technician’s qualifications. It is a two-day course and gets them to a very high standard of first aid training.”

Nobody can come near a Formula E car without having the appropriate training. It is yet another safeguard that highlights the dedication and detail to safety provision in the series. Lait adds: “There was a mandate from the FIA that before a person can work on a car they must complete the medical course and the electrical safety course. They need to have these qualifications.”

It is not just team members who benefit from such training. Marshals, who provide their time and skills for free, have received specific instruction on how to do their jobs in relation to the

Spark-Renault car. Dr Rayner says: “We have done some training with the marshals at Donington Park who have been the first to work with these cars. We have addressed how the systems in the car operate, how they should approach them, how to best immobilise them and how to use the protective equipment if necessary.”

Racing in 10 cities across four continents, the championship has worked to ensure a top-level medical team is in place at each race. Rayner says: “We are going to be relying primarily on local doctors to provide the medical support. My job, just like other series that use local doctors such as Formula One, is to make sure that medical personnel, the equipment and standards meet the FIA requirements.”

With all-electric technology being untested at this level of international motor sport, series organisers realise that a hands-on approach is necessary to bring local medical staff up to speed. Rayner will brief the medical and extrication teams the day before each event as many of

them will not have seen these cars before. Formula E will also take a team of six experienced marshals from Donington to provide a core unit with experience of these cars.

Rayner, who is also Chief Medical Officer of Wales Rally GB and Deputy Chief Medical Officer of the British Grand Prix, explains: “We want a core team of people going out to each race, that we know have the experience to detect if things are not quite right and be able to deal with these problems quickly and efficiently.”

In addition, two MDD employees will support the medical team at each event. Lait says: “We have a program in place to train the marshals for each race event around the world. MDD employees will be going out there ahead of the race to ensure that training is undertaken.”

Although there are many differences with conventional single-seaters, some similarities remain. When it comes to driver extrication, the cars are fitted with an extractable seat akin to





The Formula E medical car (left) and safety car are supplied by BMW



Specialist safety and medical equipment has been provided for the championship

those used in other global single-seater series.

One of a driver's biggest fears is fire and this is exacerbated with an all-electric racing car. "There is a huge difference between an electrical fire and a petrol engine fire, primarily the difficulty in extinguishing an electrical battery fire," explains Lait.

This is why electrical fire has been a focus of medical research in relation to the championship. "It is an issue that we have heavily researched and put a procedure in place to deal with it," says Dr Rayner. "The car has an on-board fire extinguisher and a couple of on-board fire extinguisher ports that open into the battery casing. We have specialist extinguishers that plug into those ports and can help cool the battery."

The training has already been put into practice, following a fire on one of the Virgin Racing cars during a recent test session at Donington. Lait says that the team dealt with this in exemplary fashion: "We had a small fire in testing but everybody followed the evacuation procedure.

They were extremely professional and did exactly what they have been trained to do."

Specialist equipment is a key part of the Formula E safety kit bag. Alongside fire extinguishers and protective clothing, bespoke apparatus has been designed by MDD. "We have supplied specific electrical safety equipment that includes a tool to pull an electric shock victim away from a car if they are holding on involuntarily," says Lait. "We have also designed specialist respirators in case of fire and arc flash protection, which is equipment that prevents electricity arcing to a team member."

If anybody does suffer an electric shock then Formula E is prepared for this too with each team receiving a defibrillator and training on how to use it. The traditional perils of motor sport have not been forgotten however. All the normal medical equipment required at any other event of a similar magnitude will be available.

One of the most interesting features of Formula E is its commitment to racing on downtown, city

centre, street circuits. Whilst providing an incredible spectacle and easy access for fans, it presents a number of challenges from a medical perspective. Dr Rayner says: "Racing on temporary circuits means you have to make compromises."

These compromises have to be made but not at the expense of overall safety. Dr Rayner says: "Most of these circuits are based in city centres and will have hospitals very close by. If we have a hospital that is less than ten minutes away, that will govern the level of medical provisions provided at the circuit. It may be better to take a casualty directly to the hospital rather than a medical centre at the circuit."

With so many new locations and temporary circuits that will be seeing electric racing cars for the first time, it seems a difficult task to organise all these medical provisions. The working group has put together strict procedures to ensure they are met.

"We let the event organisers and local doctors know what we expect and what the standards

are," says Dr Rayner. "We send them a medical questionnaire to fill in and this gives us an idea of what equipment will be provided."

To add another level of control, Dr Rayner personally oversees preparations of medical care for the event. "I will go out before the event to meet the medical people, inspect the situation and discuss with them exactly what is needed," he says. "I will also check the hospital situation, what facilities they have and how easy it is to access it. By the time we get to the event, all of that will have been checked and we will know that everything is in place."

With input from MDD Europe, the FIA and organisers within Formula E, medical provisions will be up to the highest standards. "It is truly a team effort," says Lait. "I am confident that the level of training, equipment and expertise that has been supplied to this series is significantly higher than any other level that has been supplied to any other series, including Formula One."

CHIEF MEDICAL OFFICER PROFILE:

# DR PHIL RAYNER

Permanent Medical Delegate, FIA Formula E Championship  
Chief Medical Officer, Wales Rally GB

*Having covered rally stages in forests and provided medical care at F1 grands prix, Dr Phil Rayner is now taking on the challenge of electric racing as the first Permanent Medical Delegate for Formula E.*



When Dr Phil Rayner was asked to cover for a colleague at an icy Mallory Park circuit when he was in his twenties he had little idea that motor sport would become a defining thread throughout his career. But he went on to rise swiftly, becoming part of the British Grand Prix medical team, the Chief Medical Officer of Wales Rally GB and a member of the FIA Medical Commission.

Throughout this time, he has made a hugely important contribution to the development of motor sport safety. In this interview he talks about those improvements in safety, his plans for the future and the time when he was the first medic on scene of a plane crash.

**AUTO+ Medical:** How did you first get involved in motor sport?

**Dr Phil Rayner:** It was 1980 and I was persuaded to go to a race meeting at Mallory Park by a colleague of mine who couldn't attend. I remember it very well because it was the day Stirling Moss made his return to motor sport. I stood at Gerrards corner in the morning and I watched the ice thaw on the lake. I went and sat in the car with the heater on for an hour, came back and watched the ice freeze on the lake. For some strange reason I came back and I've never understood why!

**A+M:** What first interested you in motor sport?

**PR:** When my colleague asked if I wanted to go I thought that it might be interesting. I met some nice, interesting and pleasant people and I have made many friends through motor sport over the years, both medical and non-medical. I've enjoyed doing it, I've enjoyed the company and I've enjoyed watching the motor sport. It has been good fun.

**A+M:** What were your experiences in the early years of your career?

**PR:** You still had to have a minimum of two doctors at a race meeting but the rescue units

provided the main support. Some of the smaller circuits and their medical centres have improved dramatically in the last decade. The organisation is now probably better than it was then but general provision of medical was of a similar standard.

**A+M:** How did improvements in medical centres happen?

**PR:** I think it was driven by two things. It was mainly driven by the UK Motor Sports Association, who has always looked very carefully at medical and safety provision for the sport in the UK. That was driven by developments coming down from the FIA and also by the people involved. This included the rising standards and levels of expectation for medical services, both within the sport and outside.

**A+M:** What has been the most challenging moment in your motor sport career so far?

**PR:** That is a difficult question; there are always five or six things that come to mind. Dealing with the first fatality that I was significantly involved with and had to manage was hard. We were running an on-the-road event on the Isle of Man which was great fun but quite frightening with people driving down the streets at 130mph in vintage cars.

There was another moment that was particularly challenging and a little exciting. It was January 1987 and we were running a rescue unit training day at Donington Park in the heavy snow. It was 2pm and I happened to look out the window and an aeroplane appeared which was very low. It crashed just outside of the circuit so we jumped in the wagon, carried the rescue unit through the snow to the field where the plane had crashed. The team cut the crew out of the aircraft, which was being used as a training flight, and probably saved their lives. They got a bravery award for the work they did that day and it was a great training experience, if not unfortunate for the crew.



Dr Rayner is Chief Medical Officer for Wales Rally GB

**A+M:** Do incidents, particularly those involving fatalities, affect you?

**PR:** Without sounding heartless, it is something in the medical profession we are used to dealing with. I have worked in intensive care where people do die so if you are working in the medical profession you become accustomed to death. It obviously has an effect on you but it is part of your job and you just have to do the best job you can for whoever is involved. That is the casualty, the casualty's family and then the of-

ficials who have been involved as well, who may not have been in that situation before.

**A+M:** As Chief Medical Officer at Wales Rally GB, how does that role differ from covering circuit racing?

**PR:** The logistics are different because I am setting up, supervising and leading a medical team that is spread over a large area and is working more independently than one at a circuit. Getting people to arrive at a certain point in the middle of a forest at 4am is sometimes

difficult but I must say they are all very good at it and rarely get lost. Obviously if you do have an incident, the control of that incident and the evacuation of the casualty requires a little bit more experience and thought than perhaps it would for a circuit. We have a very good team, a medical helicopter at the event and we have had relatively few casualties. We had one fatality some years ago in Wales but generally motor sport in the UK is safe.

**A+M:** How involved are you in the event of an incident on the rally?

**PR:** My job as Chief Medical Officer, sitting in rally control, is firstly to advise the clerk of the course as to what is going on and if we should stop the stage and mobilise a medical unit. I would mobilise the nearest medical facility and I would wait to hear from them about the condition of the casualty and if they needed any back-up or whether the situation required the medical helicopter. Once we have the situation stabilised we would work out the best route to evacuate the casualty. We have a series of designated hospitals and I will ring the hospital that the patient is going to and give them all the information on the casualty. I then sit down and write all the reports for the FIA and the MSA and sometimes liaise with the press officer if the situation warrants it. My job is very much coordination and management of the event. My days of sitting out in the forest are long gone!

**A+M:** What is the most important thing you have learned in motor sport?

**PR:** To work as a team.

**A+M:** What is the most rewarding part of your role?

**PR:** I think it's when somebody comes back who you have treated. They come along and say thank you and they have recovered well. You feel like you have done your job well and the entire medical team has performed well.

**A+M:** What would you like to see improved in the realm of motor sport medical care?

**PR:** I think we could do more training for doctors, especially the medical aspects of motor sport. The training programme that the FIA Institute and Dr Paul Trafford are developing should improve this. I hope that we can offer this to doctors attending motor sport and I think that it could also be used to help recruit. We are finding that the numbers coming into motor sport, and certainly those that are staying, are dwindling. There are a lot of older doctors but unfortunately not many younger doctors coming through.

**A+M:** You are a member of the FIA Medical Commission, what does that involve?

**PR:** It involves going to the Commission meetings three or four times a year in Paris. The Commission looks at the medical standards of FIA events, both in the form of personnel and safety equipment. We look at processes and procedures and review all reports from medical teams at events that have taken place under FIA jurisdiction. We note all the good points and address the issues we feel could be improved and we also talk about licensing circuits.

**A+M:** You are now taking on a new role with the FIA Formula E Championship. What does it involve?

**PR:** I am the Medical Delegate appointed by the FIA to develop, monitor and oversee the medical aspects of the championship. I have helped organise all the regulations and levels of equipment, which I did with the FIA. My job is to make sure that the medical personnel, the equipment and standards meet the FIA requirements.

**A+M:** What do you still want to achieve in your career in motor sport?

**PR:** I think I have done as much as I wanted to do. I have a couple more years in me I think but I am happy with what I am doing at the moment.

# CENTRES OF THE CIRCUITS

*Medical centres at top-level circuits have improved hugely over the last 30 years. From sheds on the side of a track to the state-of-the-art facilities found today, medical centres now rival top hospitals for first response and care.*

# MEDICAL CENTRE





Dr Nick James,  
Clinical Lead for Grand Prix team



Dr Gordon Falconer,  
Medical Consultant



Alan Collett,  
Medical Services Supervisor

## SILVERSTONE SAFETY

With over 100,000 fans on race day at a Grand Prix and a full roster of events across the weekend, Silverstone has one of the busiest medical centres in the world. AUTO+ Medical went behind the scenes of the British Grand Prix to see just how this medical facility operates on race day.

Before any racing can take place, all medical provisions need to be prepared. This task falls to Alan Collett, the Medical Services Supervisor at Silverstone. “I have to get everything ready and for the Grand Prix, we have a very big team,” he says. “Each person has a very specific role within the team. In the build up to the Grand Prix, our responsibility as the circuit medical team is ensuring that the place is fully stocked, fully kitted and everyone knows their role.”

His role takes on added responsibility over the course of the Grand Prix weekend. “We have 20 doctors stood trackside. We have five doctors out in five individual cars and we have eight doctors working in the medical centre. We also have eight ambulances that are purely dedicated to accidents on the track. It is a mammoth task with a lot of different people and that is where I come in to collate everyone together and make sure everyone is in the right place at the right time.”

As Medical Services Supervisor, Collett is a major lynchpin of the first response team following an accident. “An immediate response is required if a driver is injured. We will mobilise one of the track cars or if there is one, a ground-based doctor will run to the car on foot to be first on scene.”

The response is impressively orchestrated and ensures first-rate care for the injured party. Collett continues: “Someone is there by the patient’s side within seconds. It is all coordinated and that patient will then be brought back to the

“One of the safest places to fall ill is at a motor racing circuit,” according to Dr Gordon Falconer, a veteran medic with over 40 years experience in motor sport.

He would know as he has seen medical services in the sport improve dramatically over the years. Falconer, who began his medical career working as an orthopaedic heart surgeon in London, remembers his first experience at a motor racing circuit in the 1960s: “I had just qualified and was asked if I would help out at Brands Hatch. I agreed and went to the circuit where I met the Chief Medical Officer. He gave me my equipment, which was just an anvil of morphine and a tourniquet. I was shocked.”

Thankfully, facilities and equipment have improved hugely since then. Long gone are the dark days when injured drivers would be left unattended on an ill-prepared medical centre floor surrounded by cigarette ends. Now, medi-

cal facilities at FIA-approved race circuits can rival the very best hospitals across the world. A wealth of medical personnel is on hand and has access to a variety of safety kits and fast-response vehicles to provide life-saving treatment to any injured party.

Falconer attributes the advances made in safety and medicine in motor sport since the 1970s to two men: Bernie Ecclestone and Prof. Sid Watkins. He says: “The massive improvement came when Bernie asked Sid to step in to Formula One and put things straight following a number of fatalities. From there, it rapidly improved and continues to do so.”

Watkins demanded better safety equipment at race circuits and soon had in place a medical team with a range of expertise. As the number of fatal accidents decreased, a formal set of standards designed to govern the required medical facilities for a Grand Prix were established by

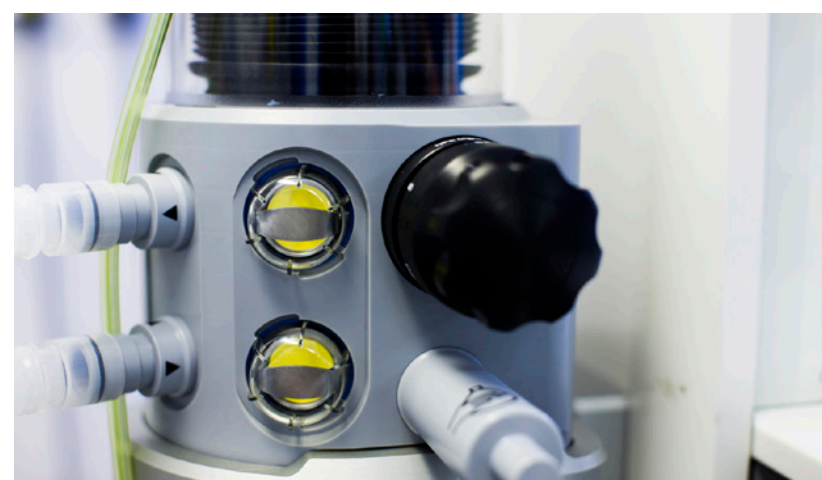
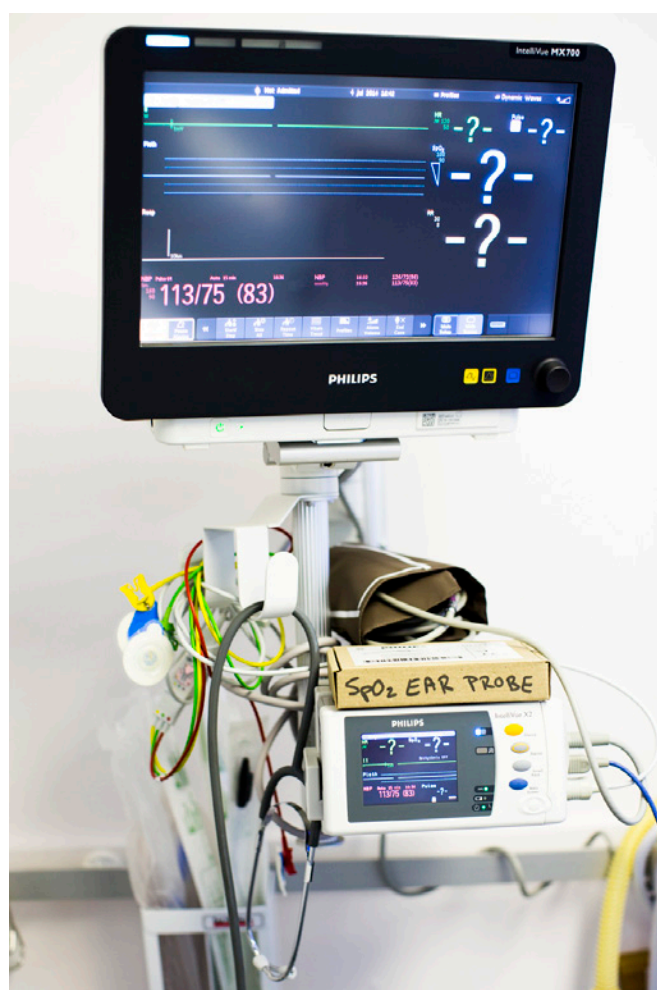
the FIA. This framework has been developed and now helps to shape the world-class facilities available at every track the Formula One circus visits.

Now, when you open the doors to a medical centre during any major motor racing event, you would be surprised at what you find. Each Medical Centre is like a mini-hospital in itself with over 50 members of staff and all of the equipment needed to deal with immediate care.

A top-level medical centre can cater for any emergency. The purpose-built facility typically houses x-ray and resuscitation rooms, a burns unit and a minor treatment centre. On hand is a team of doctors including specialist anaesthetists, general and plastic surgeons and general practitioners. A team of nurses ably supports them. The job of the medical centre team is to stabilise the patient before moving them on to one of the assigned hospitals equipped with a major trauma unit in the local area.



A top-level motor sport medical centre contains all of the latest equipment to cater for any emergency.



medical centre. We ensure we are in constant contact through the radio to be aware of what is going on even before the patient has arrived at the medical centre.”

If the patient is seriously injured, they will be stabilised and transferred to the nearest hospital by helicopter. He adds: “We have an air ambulance positioned outside which we can use to take the patient to a major trauma unit.”

But it is not just incidents on the track that the medical team must deal with. As Collett says: “This place turns into a town over a Grand Prix weekend. There is camping around the circuit with upwards of 100,000 people until Sunday evening and they bring with them pre-existing medical conditions and some gain minor cuts and bruises while here. We also have to deal with severe issues where people suffer heart attacks and strokes. As the number of people here is similar to a small town, you would expect these things over the course of a weekend.”

Constant communication allows the medical centre to prepare for any incoming casualty, sorting out what equipment and expertise will be needed. Dr Nick James, the Clinical Lead for the Grand Prix team, says everyone has a major role to play. He says: “We have two trauma units with an anaesthetist and a surgeon in both teams. We also have two general practitioners in the medical centre and I specialise in burns and plastic surgery.”

No time can be wasted and it is therefore imperative that the correct team can be put in place to handle the injuries of the patient.

Silverstone also boasts an impressive collection of potentially life-saving equipment. “The medical centre is equipped as a small trauma unit,” says Collett. “We have a minor treatment centre that can deal with small injuries but we also have two wards for longer term injuries where a patient can be looked after by a nursing team.”

The Silverstone medical centre is set up to deal with the most serious injuries. Collett continues: “We have an x-ray facility, a dedicated burns unit and a resuscitation room that is equipped as a full resuscitation facility with every piece of equipment needed. We also have anaesthetists and surgeons working in here so if need be, we have the facilities to do exactly what we need to do to save someone’s life.”

With such high quality equipment and vastly experienced medical professionals, it is no surprise that Dr James is so proud of the Silverstone medical team. As he puts it: “The team here is second to none in the world. The vast majority of the doctors here are trauma trained through advanced trauma life support courses. We train regularly, meet regularly and make sure we have the right expertise in the right place doing the right job.”

This determination to continually push the boundaries of medical care has seen huge leaps forward in racing safety, exemplified by the Silverstone Grand Prix medical team.

### GRAND PRIX MEDICAL TEAM IN NUMBERS

- 20** trackside doctors
- 5** medical car doctors
- 8** medical centre doctors
- 2** anaesthetists
- 2** surgeons
- 2** general practitioners
- 2** burns specialists
- 6** medical centre nurses
- 8** ambulances (Trackside)
- 6** ambulances (Public side)
- 1** medical helicopter

# INSIDE THE F1 MEDICAL CAR

FIA Formula One Medical Rescue Coordinator **Dr Ian Roberts** talks through the various pieces of high-tech equipment and medical devices inside the F1 medical car at every race.



## LARGE MEDICAL BAG

“With a fold-out design, the large medical bag is produced by MDD Europe and contains a wealth of equipment. On one side we keep all airway equipment, from airway adjuncts and tubes to a video laryngoscope (to view inside a patient’s throat). We have a small portable ventilator and various bits of kit, including a tracheostomy tube, if we are working with a compromised airway.

“In the other side of the bag we keep all the circulation equipment. We have intravenous equipment along with fluids and dressings. Splints for limbs, including a special splint for the pelvis, are included in this portion of the bag. We carry a neck collar in here and a small Philips monitor so we can view electrocardiogram, saturation, pulse, blood pressure and other medical information.”

## SUCTION BOX

“If a casualty has any fluids in their mouth, such as blood or vomit, we can use the suction box to clear these hazards. It is a large item but is useful for the suction power it provides.”

## WATERJEL BAG

“This small red bag contains dressings for burns. We have bespoke dressings with eyeholes for the face and various designs for hands. The bag also contains Diphoterine, which is used to neutralise hydrofluoric acid burns from electrical equipment.”

## FIRE EXTINGUISHER

“We carry a fire extinguisher in the boot for use in the medical car or as a back-up if we are first to arrive at the scene of an accident.”

## PHILIPS DEFIBRILLATOR

“Provided free of charge by Philips, the defibrillator is very compact and can be used to deal with any cardiac arrest. I have trained all FIA technical staff to use the defibrillator in case of a heart failure in the scrutineering bay or pit lane. We have an extremely good relationship with Philips who often provide us with state of the art equipment before it even reaches hospitals.”



**DASHBOARD**  
 “This is how we control the lights on the car. The buttons all correspond to the colours they display. Yellow and white are warning lights, located on the top of the vehicle and front and rear respectively. The green button illuminates the medical car sign in the rear of the car and alerts any vehicle behind to overtake. Finally, blue operates the siren, which we use when entering the pit lane at speed, usually after the opening lap of a race.”

**RADIO**  
 “We have two red buttons that operate the radios. The top one is for the digital radio and this is the channel we primarily use. Most of our communication comes through [FIA F1 Deputy Race Director] Herbie Blash in race control, who can also patch us in to team radio so we can hear if a driver is communicating following an accident. The bottom button is for the analogue radio which is used in the event of the digital radio failing. Medical car driver Alan Van der Merwe can operate the radio with buttons on his side of the dashboard and I can operate it with buttons on my side.  
 “One of the developments we have had this year is, if there is an incident, one of the operators in race control will actually patch the team radio through to me via the analogue radio so I can hear what is being said between the team and the driver. If he is reporting any injuries, then I know before I get there. If it is completely silent then we are aware that something is seriously wrong.”

**VISUAL SCREENS**  
 “We have three screens in the car. The top screen shows us a live feed of the race so we are aware of any incidents that occur. Below that is a mini iPad built into the console displaying timing information for all cars on track. Finally, the iPad in front of me acts as a GPS monitor showing the location of the drivers. It also highlights yellow flag sectors, red flags, safety car periods and even displays the g-force a car has encountered in an accident.  
 “I get race control messages on the screen too. We keep all the documents in the car including timetables and the car has its own email address so if we need any additional information it can be sent to us.”

**ELECTRICAL GLOVES**  
 “We carry rubber electrical gloves that can protect against a lethal voltage. To protect the electrical gloves being cut when around sharp carbon fibre, we carry a pair of strong over-gloves.”

**SMALL MEDICAL BAG**  
 “I carry a small bag that has immediate airway equipment, tools to gain IV access and tourniquet if there is any bleeding from a limb. This is very important as it has everything that you want in the first couple of minutes and there is a variety of airways in there and a method of ventilation.”



THE ROAD BACK:

# MIKE CONWAY

*In the closing laps of the 2010 Indy 500, Mike Conway made contact with another car and was sent high into the catch fencing. Suffering multiple injuries in the crash, Conway details his long road to recovery to AUTO+ Medical.*



**AUTO+ Medical:** What do you remember about your crash at the Indy 500?

**Mike Conway:** I didn't lose consciousness so I remember everything. Up until then it was a good race. We were coming from the back and we had enough fuel to go to the end as everyone in front of us was running out. I was right on the backside of Ryan Hunter-Reay and I was getting ready to pass him in between turns three and four. Sadly, he had a fuel surge right when I didn't need him to have one. I tried to avoid him by diving down into the inside grass but clipped his rear corner and from there I was just a passenger. Once the car came to a stop I realised I couldn't get out by myself so I waited for the medical team to get me out. I ended up with a broken leg and a compression fracture of one of my vertebrae.

**A+M:** How was the care provided by the medical team in the initial aftermath of the crash?

**MC:** It was very good. They really know what to do in those situations. As a driver, you just want to get out and walk away from it if you can but obviously I couldn't so I just let the guys take care off me. They gave me all the care and attention I needed; not just at the track but in the next few months after.

**A+M:** What were your emotions on your first night in hospital?

**MC:** I'd never been hurt in a race car before so it felt a little odd to be in hospital. You are a



Conway celebrates victory at the 2014 Toronto IndyCar race, following a full recovery from injury.



On the last lap of the 2010 Indy 500 Mike Conway's #24 car collided with an out-of-fuel Ryan Hunter-Reay, sending Conway backwards into the catch fence.



driver so you don't really think about it too much. As soon as it happens you want to know when you can get back in the car. It's just like if you fall off your bike, you get back on it. It was just one of those things really. So as soon as I was ready and fit enough to get back in one, I did so.

**A+M:** How difficult was the rehabilitation process?

**MC:** It was just so frustrating. When they took the cast off my leg I was shocked because it didn't look anything like a leg. It looked horrible because it was so swollen and discoloured. You realise that it is not just as easy as you think it is going to be. It took a long time and you just have to take it day by day. If you start thinking about where you want to be in six months it can get very frustrating. I had a great guy with me called Roger Cleary, he is a great physiotherapist

and he just guided me through it. I had him with me for the first half of the next season when I started racing again and that was really helpful. He did a great job and without him it would have taken double the time to get fit again. So I am really thankful to him and all his efforts.

**A+M:** Did any of your injuries cause you problems when you stepped back into a racing car?

**MC:** The first thing was the struggle with left foot braking in an Indy Car. With the brake pedal being so hard, I wasn't sure if, with all the vibrations in the car, I was going to be ok. The first time I got back in I braked into a hairpin and it really hurt. I stuck with it the whole day though and didn't tell anyone. My physiotherapist and I worked on a few different things and by the next test it didn't really bother me. We

had to look after things for the whole year but it wasn't too much of a problem.

It still swells up now and then and it can ache for no reason but it will be an on going thing probably until I am an old man in a wheelchair.

**A+M:** Is there anything you would like to change in terms of circuit safety or aftercare?

**MC:** The aftercare is superb so I wouldn't change anything on that front. In terms of ovals, I am not a big fan. I had a couple of big shunts and I just didn't enjoy them. I wanted to race and enjoy it. Racing is what I have been doing since I was eight years old and to not enjoy it was just ridiculous. It doesn't even sound right saying it now. It was time to move on and it has proved a great decision. I have been winning a lot more races in different championships and still being able to do street circuit races in IndyCar is very fortunate.

**A+M:** Do you think there is anything more that can be done about fencing issues in motor sport?

**MC:** They are always looking at ways to improve it. It is hard to enforce it though. When they introduced the SAFER barrier, that instantly proved to be safer and they got all the circuits to agree to install them. It is constantly evolving though and I am sure they are always working on the fencing issue to make it safer. I don't really have any input on that because it is up to the experts but you hope to always push the boundaries of safety. You always try to evaluate safety at circuits and envisage every scenario but sometimes you end up on the wrong side and have a bad accident. That is where the FIA, IndyCar and other governing bodies are so good at pushing the limits and make things safer. You can see they are constantly thinking about it so I think they are doing a good job.

# SCIENCE

## TRAUMATIC BRAIN INJURY IN MOTOR SPORT

*FIA Institute Fellow **Dr Steve Olvey** examines the issues related to traumatic brain injury in motor sport*

Since the first automobile race took place from Paris to Rouen, France, in 1894, Traumatic Brain Injury (TBI) has been and remains the leading cause of death in all forms of motor sport. The overall incidence of death in motor sport has declined markedly since the early days of racing when there were no seatbelts, decent helmets, or roll bar protection. Still, in the 1960s and 1970s, the mortality rate from head injury remained high. Reportedly, an average of one in seven drivers died each year from severe brain injury and/or burns. Improved restraint systems, better helmets, and increased in-cockpit protection, coupled with the addition of dedicated on-track response teams, bet-

ter emergency medical services generally, and improved in-hospital intensive care, meant that survival improved markedly throughout the 80's and 90's. During this same period neurosurgeons became surgically more aggressive in treating TBI, which also helped to improve mortality. Following the death of Ayrton Senna in 1994, and after several similar tragedies in the United States, the Head and Neck Support (HANS) device was introduced and made mandatory in several series. The HANS basically keeps the head, neck, and torso moving in the same direction by tethering the helmet to a collar and head support arrangement anchored



Airborne objects such as a piece of debris from another vehicle may impact the visor area but new visor material has been added to strengthen this part of the helmet. Tests performed by the FIA Institute have shown that this new visor offers much greater protection for this type of injury.

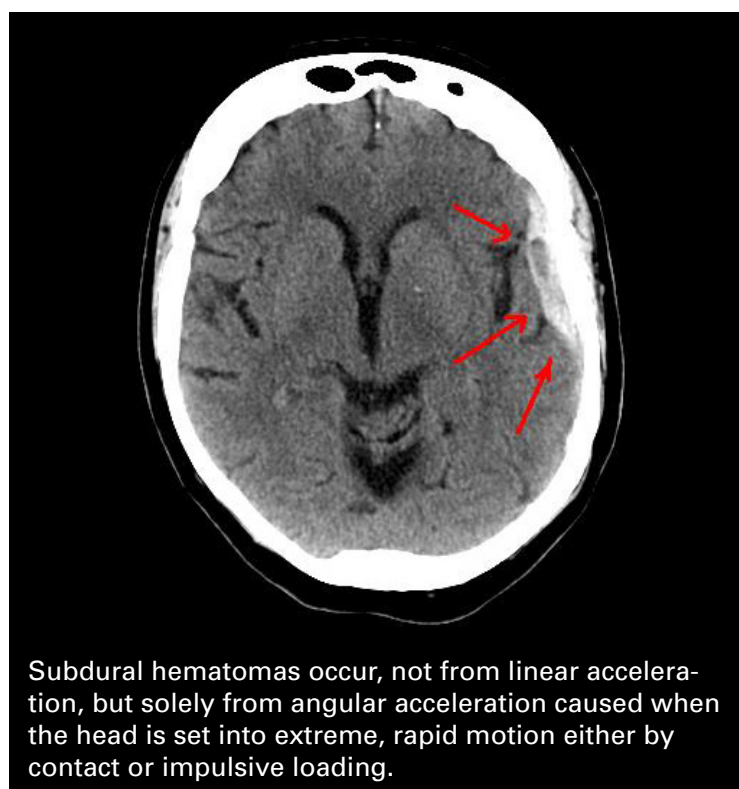
by the shoulder belts. Currently, through the combination of the six-way restraint systems, the HANS Device, optimal padding within the cockpit, improved energy management provided by the vehicle itself, and safer barrier, the incidence of severe head injuries has decreased markedly. Since the HANS was introduced, basilar skull fracture, an injury that may cause the head to become separated from the spine resulting in death, has been virtually eliminated. Basilar skull fracture caused the deaths of several drivers in the late 1990s through to the early 2000s. Yet because the head is the most exposed part of the race driver's anatomy, severe and fatal head injuries can still occur. Direct impact by an airborne object such as an errant wheel, or piece of debris, or impact with a permanent structure, such as a support pole, or with an interior part of the vehicle, are now the most common causes of severe or fatal TBI.

Less than 15 years ago, it was not uncommon to hear someone remark after a serious accident: "He's really lucky, he only suffered a concussion." We now know that concussion is not just a bump on the head. Classified as a mild TBI, concussion is now considered to be quite serious with chronic alteration of mental function a distinct possibility in cases where "too" many concussions have occurred.

**SEVERE TRAUMATIC BRAIN INJURY**

Head injuries can be classified into five general types: skull fracture, penetrating injury, focal and diffuse blunt injury, and blast injury. Skull fractures result primarily from a direct blow to the head and may or may not damage the underlying brain.

Skull fractures in motor sport are now relatively rare, occurring only in the most severe crashes due to modern helmets and their almost indestructible outer shell. The one remaining area of the helmet that is still vulnerable to penetration



Subdural hematomas occur, not from linear acceleration, but solely from angular acceleration caused when the head is set into extreme, rapid motion either by contact or impulsive loading.

is the visor. Airborne objects such as a spring or piece of debris from another vehicle may impact the visor area with sufficient force to penetrate the visor and intrude into the skull, possibly fracturing facial and orbital bones. Subsequent eye and brain injuries can occur as in the case of Ferrari driver Felipe Massa who, in 2009 was hit over the left eye by a spring off another car. The impact velocity was over 160mph. Since this accident, new visor material has been added to strengthen this part of the helmet. Tests performed by the FIA Institute have shown that this new visor offers much greater protection for this type of injury. Penetrating injuries directed through the helmet proper in motor sport are extremely rare, again due to the strength of the modern racing helmet's outer shell. With an appropriate shape and sufficient force, however, this type of injury can still occur. Modern suspension designs on open wheel cars have greatly limited the chances of a suspension piece penetrating the head or face of a driver, and wheel tethers serve to prevent wheels torn free during a crash from impacting the driver's head.

Blast injuries are now extremely rare in motor sport due to proper fuel management and protection, but conceivably could occur from an explosion, during a terrorist attack, or other obscure cause unrelated to the sport. TBI in modern motor sport, therefore, is most often a focal or diffuse brain injury, usually a combination of the two.

**FORCE APPLICATION IN TBI**

Forces causing injury are applied to the head in two ways. Either by direct impact (also called contact loading) or by indirect impact (impulsive loading), where the force is directed elsewhere to the body but causes the head to violently move in response. An example of impulsive loading would be the resultant head injury suffered by an American football quarterback who gets violently hit mid-torso by a defensive player attempting to bring him down. The "whiplash" response of the head, if violent enough, can cause the brain to be affected. A violently spinning race car, with no impact to the head, has been shown to cause enough angular acceleration to cause at least a concussion. The recent career ending crash of Dario Franchitti in Indy Cars bears this out.

**FOCAL BRAIN INJURY**

Focal brain injuries result from forces applied to a well defined area of the head. Direct force to a defined area can cause one or more of the following injuries to occur: cerebral contusion, subdural and epidural hematoma, and intracerebral hematoma. Focal injuries occur in nearly half of all TBIs and are responsible for two thirds of the deaths in the general population. Helmets are quite helpful in reducing this type of injury.

**CONTUSIONS**

Cerebral contusions can occur in response to a direct blow to the head or to the helmet of a driver. Forces of sufficient strength will result in the surface of the skull bending inward in re-



Dr Stephen Olvey is an associate professor in the Department of Neurological Surgery at the University of Miami, Miller School of Medicine and a founding Fellow of the FIA Institute. He directs the neuroscience intensive care unit at Jackson Memorial Hospital in Miami and is also a member of the American College of Sports Medicine's Motor Sports Safety Task Force as well as a medical consultant to the IndyCar Series.

sponse to the impact. On rebound, the skull may tear vessels near the surface of the brain causing bleeding and the development of a contusion or small collection of blood similar to a bruise elsewhere. Contusions can be relatively minor or may "blossom", or enlarge to cause major disruption of brain function and possibly death. Contusions are of two types: 1. coup contusion, or 2. contrecoup contusion. A coup contusion develops directly beneath the impact area.

Lewis Hamilton spins on the opening lap of the 2014 Hungarian Grand Prix. A violently spinning race car, with no impact to the head, has been shown to cause enough angular acceleration to cause at least a concussion.



A contrecoup contusion, on the other hand, develops within the brain directly, or near directly opposite to the coup contusion. The size of a contrecoup contusion is determined by how much force and skull motion was caused by the original impact to the head. A strong impact to the head will set the cerebrospinal fluid (CSF) in motion toward the impact area. The CSF has a greater density than the brain. Because of this, after the initial impact of the brain with the skull, the brain is displaced away from the initial impact area. If the forces are severe enough the brain will make an impact with the inside of the skull opposite to the initial impact area. Contrecoup contusions can also occur with impulsive loading, as when the head is set into extreme motion by forces generated away from the head; an example of this would be “shaken baby syndrome”. A race car hit repeatedly from all sides in a massive crash could result in this type of in-

jury. Contusions will absorb in time as the brain heals, but can be fatal if they increase in size enough to displace the brain downward causing it to herniate through the foramen magnum, the opening where the spinal cord joins the brain. Death can occur rapidly if not treated early by medication and surgical decompression.

**HEMATOMAS**

Epidural hematomas are linked to linear skull fracture and are therefore rare in motor sport due to the protection offered by the helmet. If a skull fracture does occur, and the fracture line crosses a blood vessel on the surface of the brain, bleeding will occur between the skull and the brain causing increased pressure inside the skull that, if severe enough, can potentially cause herniation. Subdural hematomas occur, not from linear acceleration, but solely from angular acceleration caused when the head is set into extreme, rapid

motion either by contact or impulsive loading. This sudden rotational movement can cause tearing of small veins, called bridging veins, that course between the brain itself and the protective membranous layer covering the brain, called the dura. Large accumulations of blood can occur in this instance placing pressure on the brain. If not evacuated, these hematomas can grow rapidly and also cause fatal herniation syndrome.

**DIFFUSE BRAIN INJURY**

Diffuse brain injuries actually run along a continuum based on severity with concussion being the least severe, and diffuse axonal injury (DAI) the most severe. Both concussion and DAI are caused by angular accelerations of the head as it is set into motion by traumatic forces. The brain within the confines of the skull does not act like a homogeneous object floating within the CSF. The brain has differing levels of density and

composition, and is comprised of both grey and white matter, structural entities, anchor points, and blood vessels. Anchored at its base where it joins the spinal cord, the brain, when set into angular motion, causes strain and shear patterns that vary as the intensity of the applied forces increase. The more intense the energy the deeper into the brain the damage goes. Therefore, the magnitude, direction, and duration of any applied angular force determines where and to what extent the brain is injured.

In helmeted sports such as motor sports, it is important to realize that the helmet, due to its added mass, will increase angular accelerations of the head. Angular accelerations are increased as a helmet’s mass moves away from the center of rotation caused by any applied force. In children, this is extremely important because a child’s head is smaller than an adult’s and therefore has less inertia. Weighing less, a child’s

Direct impact by an airborne object such as an errant wheel or piece of debris, as happened to Felipe Massa (pictured), is one of the most common causes of severe or fatal TBI.



head will experience greater motion in response to an applied force. Additionally, the neck muscles and ligaments in children are not nearly as developed as an adult's, allowing the head to move farther and more rapidly when set into motion. The FIA Institute has studied this problem and has developed a suggested standard for youth helmets. Helmets meeting this standard are now available worldwide. It is important to realize that there is no such thing as a concussion-proof helmet. In fact, helmets have very little effect on the mitigation of concussion.

#### **DIFFUSE AXONAL INJURY**

DAI is the most severe form of diffuse brain injury. Axons are the brain's pathways for nerve impulse propagation. Damage to axons from TBI is the main cause of prolonged coma. Like concussion, DAI is caused only by angular acceleration. Forces strong enough to cause DAI will also result in associated other focal and diffuse injuries. DAI does not require the head to impact an object or surface. In most forms of motor sport, the velocities involved in high g crashes can easily cause angular accelerations of sufficient magnitude to cause DAI.

Severe TBI is not always catastrophic. In major series, dedicated emergency response teams who often arrive on the scene of a crash within seconds do not allow an injured driver to become hypotensive, too low a blood pressure, or hypoxic, too low an oxygen level. If either

of these problems are allowed to occur in conjunction with a severe head injury, secondary injury to the brain can result. These secondary injuries are due to a rapid cascade of chemically induced inflammatory responses that can permanently destroy certain brain cells and severely damage others. The brain has a remarkable ability to heal itself if it has adequate blood flow and oxygen delivery throughout the post-injury period. Unfortunately, this recovery rate is rare in highway crashes due to the time involved in getting emergency care to the scene.

#### **CONCUSSION**

The accepted definition of concussion has recently changed and has been simplified. It is now defined as: "An alteration of brain function resulting from applied bio-mechanical forces due to trauma". Importantly, unlike older definitions, one does not have to have been unconscious to have a concussion. Nor does one have to have had either retrograde, or anterograde amnesia. To be diagnosed as having a concussion, there does need to be some evidence for altered brain activity. The symptoms and signs of concussion are variable and involve any or all of the following: Change in mental status, difficulty with balance and/or coordination, altered motor skills and reflexes, impaired judgment, difficulty with problem solving, gastrointestinal issues, altered senses, primarily vision and hearing, and almost invariably a headache which

is the number one symptom, present nearly 100 per cent of the time.

Because the symptoms and signs of concussion can be delayed for up to several hours, it is important to have a high index of suspicion for concussion. In motor sport, this means suspecting a concussion following any incident that may result in driver injury. Safety personnel, fellow competitors, officials, crew members, and friends and family all have to be aware of concussion signs and symptoms. To make the diagnosis of concussion easier, one of the available, rapidly administered neuro-psychiatric tests should be used to determine if altered brain function is definitely present. It is much safer to remove a driver and investigate through testing than to risk the possible aftermath due to dangers not only to the driver in question, but to other contestants, personnel associated with the running of the event, and the spectators as well.

Tests such as ImpACT (currently the gold standard for rapid neuro-psychiatric testing), the King-Devik test, or the SCAT tests 2 and 3, are used for this purpose in most professional sports organizations as well as several secondary schools and universities throughout the world. The advantage in using King-Devik or SCAT is that the tests can be administered very quickly, they do not require a certified technician, and they are accurate without requiring a baseline. ImpACT, on the other hand, takes longer to administer, 35-40 minutes, and requires a certified examiner. ImpACT does have the advantage that there is no “learning” on repeated tests. Thus, tests can be repeated as often as needed to determine when baseline return of function has occurred. Normalization to baseline is thought to signal healing. SCAT and King-Devik do not have this advantage. Many organizations use ImpACT for baseline testing and to signal recovery and possible return to competition, but

use King-Devik or SCAT for immediate removal from competition and initial diagnosis.

It is extremely important that a concussion has healed completely before return to competition is considered. For many years, it was left up to the driver as to whether or not he returned to driving. If there was no loss of consciousness, drivers were often allowed back into competition the same day. One driver in the 1950s, who was unconscious from a crash on Friday night, drove on Saturday and Sunday with no recollection of the entire weekend. We now know that repeated concussions can have a cumulative effect, and if they occur too close together, before healing has been allowed to occur, this effect is likely magnified. A form of early dementia, called CTE or Chronic Traumatic Encephalopathy, has been identified not only in American football players as is often thought, but also in boxers, hockey players, individuals in several other contact sports, and victims of blast injuries from Iraq and Afghanistan.

Evidence for this entity is accumulating rapidly and research into concussion identification, prevention, and treatment has intensified. Certain groups have been found to be more prone to concussion. These include persons with ADD, migraine, and the Apoe alpha gene. Women are more prone to concussion than men, and it does seem to run in families. There is soft evidence that cooling an athlete to at least normal temperature immediately after a suspected concussion does lessen the symptoms and duration of the injury. Temperature elevations in drivers of closed wheel cars have been recorded as high as 41°C while competing.

Treating a concussion is multifaceted and applied in stages. At the time of recognition, the athlete must be immediately removed from competition and put to rest. This means absolute rest, both physical and mental. No reading, no video games, no television, no activity other

than minimal acts of daily living while sitting or at bed rest. If travel by automobile is a must, the athlete should ride in the back seat to avoid the possibility of being hit by an inflating air-bag in the event of an accident. This rest period must last until the patient is asymptomatic. This includes being headache-free. It is now felt by most experts that treating symptoms will hasten the resolution of a concussion.

Treatable symptoms include headaches, vertigo, nausea, vomiting, anxiety, insomnia, and depression. Once asymptomatic, the resumption of normal daily activities can resume. Light exercise is permitted once neuro-psyche tests have returned to baseline. Walking, riding a stationary bicycle, or jogging are allowed. If symptoms reoccur, then rest must be prolonged. Exercise can be gradually increased and the introduction of sports specific activities can begin in the third stage following rest and early mild exercise. For a racing driver these activities may include video games, simulators, and driving a personal vehicle. While using a simulator, a driver should show consistent and competitive times. If the athlete continues to be asymptomatic, practice in a real setting can begin under observation, and if approved by the officials, racing competition can resume.

#### SUMMARY

Racing remains a dangerous sport but huge strides have been made regarding increased survival and limiting disability. Severe brain injury remains an issue but work is constantly being done through research and development to decrease the incidence. What was once considered rather benign is now known to be quite serious concussion. Research into concussion is in its relative infancy but is increasing at a rapid rate as limiting concussion is considered an emergency among the young in many traditional sports. Football, American football, and hockey have task

forces now involved in solving the concussion epidemic. In motor sport, we also have this issue. Children are entering motor sport competition at very early ages and are progressing rapidly up the competitive ladders. With close competition concussions are bound to occur.

We are a step-up on traditional sports with a youth helmet standard, but there remains work to be done. The FIA Institute is dedicated to developing guidelines and recommendations for removal from competition, diagnosis, and safe return to competition of motor sport participants of all ages with emphasis on the young to prevent recurring injury to the brain over time. For drivers who have suffered too many injuries to the brain during their careers, research should point to early recognition of the onset of chronic disease and therapies to mitigate the course of the disease.

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# UPCOMING EVENTS

- 12.09.14**            **FIA WORLD MOTOR SPORT COUNCIL, BEIJING**
- 18.09.14**            **FIA INSTITUTE MEDICAL ADVISORY PANEL, PARIS**
- 18.09.14**            **FIA INSTITUTE RESEARCH COORDINATION GROUP, PARIS**
- 4-5.10.14**           **SERIOUS ACCIDENT STUDY GROUP, SINGAPORE**
- 18.10.14**            **FIA MEDICAL COMMISSION**
- 12-14.11.14**        **FIA PAN-AMERICAN MEDICAL CONFERENCE, ALCAPULCO**
- 1-2.12.14**           **MEDICAL SUMMIT/CMO SEMINAR, DOHA**

**EDITOR: MARC CUTLER**  
**DESIGNER: SUE FORDHAM**