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*David Cote (right) greets his sister Sheridan as she comes off the ice after she a hockey game in an Ottawa-area hockey arena, Thursday December 15, 2011. David's father Larry, now aware of how repeated knocks can damage the brain, wonders what he could have been thinking when he cheered along with other parents every time his son Dave or a teammate landed a punch or doled out a solid check that sent an opponent reeling.*  
*THE CANADIAN PRESS/Fred Chartrand*

TORONTO - Sidney Crosby, Claude Giroux, Chris Pronger — the names of NHL players sidelined by concussion have been piling up like combatants in a bench-clearing brawl.

No other issue has so dominated the hockey world in 2011 as the growing list of players taken out of action by what was long viewed as a minor hazard of the game, but now is increasingly recognized as a serious injury that can have lifelong and irreparable effects on the brain.

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"One idea was that you had to be knocked out in order to have suffered a brain injury before, and now we know you don't have to be knocked out," says Toronto neurosurgeon Dr. Michael Cusimano. "We know you don't even have to sustain a direct blow to the head, that it can be a shock wave that affects your brain.

"Also multiple concussions over time can have permanent effects," a fact many players in sports like hockey, football and rugby, coaches and the public didn't really appreciate until recently, says Cusimano.

"I think astute doctors always knew it and it would make common sense. But it wasn't out there and generally accepted."

That perception of concussion changed dramatically in January when Pittsburgh Penguins captain Crosby was forced off the ice for 10 months to recuperate from back-to-back blows to the head. Two weeks after his Nov. 21 return, he's been sidelined again with "concussion-like" symptoms. But it isn't only the travails of the NHL's most celebrated player that has brought the brain injury into such sharp focus this year.

The deaths of three hockey enforcers — Derek Boogaard, Rick Rypien and Wade Belak — underscored the destructive psychological and behavioural fallout that repeated brain traumas can leave in their wake.

Depression. Aggressive behaviour. Poor impulse control. Substance abuse. Boogaard died in May of an overdose of alcohol and oxycodone; Rypien was found dead in his home in August; two weeks later, Belak died in an apparent suicide.

After his death, Boogaard's family donated his brain for study to Boston University, where researchers are trying to untangle the connection between repeated brain rattlings and an incurable, progressive condition known as chronic traumatic encephalopathy, or CTE.

Researchers at the Center for the Study of Traumatic Encephalopathy recently reported on the state of Boogaard's brain, one of four from deceased NHL players they have examined along with dozens from former football players and other athletes.

The brain of fist-wielding tough guy Reggie Fleming, who died at 73 in 2009, was ravaged by CTE. Enforcer Bob Probert, who died last year of heart failure at 45, and prolific scorer Ricky Martin, dead in March at age 59

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of a heart attack while driving, both showed the hallmarks of CTE, though far from the extent seen in Fleming's brain.

"That's what makes Derek Boogaard's brain so remarkable at age 28," says neurosurgeon Dr. Robert Cantu, co-director of the Boston brain research centre.

While the signs of CTE were at an early stage — including deposits of a protein called tau that's associated with dementia — the fact that such damage existed at all in one so young is cause for alarm, says Cantu.

"And that's what scares you a lot when you look at Derek's brain, because he already had a significant though not flagrant amount of it," he says. "If he'd gone on to die at 70, his brain probably would have been riddled with it."

Researchers now are discovering that it isn't just repeated concussions from taking shots to the head, either from fists or being slammed head-first into the boards or onto the ice, that is leaving devastating marks on the delicate organ that is the brain.

Cantu says it isn't necessary for there to be forces at the concussion level to impart brain damage if there are enough of them.

"Concussion is in the eye of the storm right now," he says. "But the next eye of the storm, I predict, will be sub-concussive blows, because (players) are receiving thousands of them every year in three or four months of activity in some of our collision sports.

"And over a lifetime of participation, especially if you start early, that's a lot of brain trauma."

Larry Cote, now aware of how repeated knocks can damage the brain, wonders what he could have been thinking when he cheered along with other parents every time his son Dave or a teammate landed a punch or doled out a solid check that sent an opponent reeling.

"He played a tough game, for sure," the Ottawa father says of his son, who first strapped on skates at age four, then moved through the amateur competitive ranks to the junior D Lambeth Lancers in his late teens. "He wasn't involved in a lot of fights, he wasn't a fighter, but he was involved in playing hockey the way you see it on TV.

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"And everybody out there that plays hockey certainly imitates what they see the NHL players doing. And every parent out there encourages that because none of us knew the difference."

Like so many, Cote subscribed to the notion that has long permeated competitive sports: if you get injured on a play, shake it off and get back in the game.

"That is the way our generation thought and, of course, we conveyed that to our children."

But when his son's head smacked the ice during a nasty fight two years ago, causing a concussion that left him incapacitated with daily headaches and other symptoms, Cote said "enough."

Dave Cote doesn't know how many concussions he sustained over the years because he never saw a doctor after getting his "bell rung" — not until, that is, the one that took him off the ice for good.

"That was me probably not wanting to know if they were actually there and at the same time thinking they weren't that big of a deal."

But the six-foot-three, 200-pound former winger knows he had at least four or five just in his last few months on the team. "The only way I could tell is I was beyond emotional, and that just isn't me ... I'd just be sitting and having a conversation and burst into tears for no apparent reason."

It's been a long road back, coming to grips with losing the game he loves and overcoming the lack of concentration and other cognitive deficits so he could complete his business degree at the University of Western Ontario this year.

And while Larry Cote is relieved to see his son improving — enough that Dave made the dean's list — he lives with the knowledge that he was partly responsible for putting his son in harm's way, even if it was unknowingly.

"I should have been smarter, somehow," says Cote, his voice thickening with emotion. "So yeah, I have total guilt and I will for the rest of my life on this one."

Researchers can't say with any certainty what the future holds for athletes whose brains have been repeatedly knocked about in the pursuit of sport. Cantu says scientists need to study a lot more brains, especially those of players who exhibit no symptoms of brain damage, live long lives and die of

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natural causes, so they can compare them to those known to have suffered multiple head traumas.

Another key question is why some athletes are susceptible to CTE while others aren't, despite taking repeated blows to the skull.

"Unquestionably, there are as yet unidentified genetic issues," he says.

"There are a whole host of other possibilities, including how young the trauma started, how close together the traumas were. What scares me a lot is we have CTE in someone as young as 17 and another boy 18 and one 21."

Besides answering basic biomedical questions, Cusimano says research is needed on how to prevent brain injuries from occurring in the first place.

While the NHL has implemented new rules and tougher penalties to cut down on concussion-causing head shots, Cusimano says a massive culture shift is needed to make any headway on prevention.

"We don't know how to change people's opinion very well about that. If we change rules, does that change the behaviour or do we have to give them an economic incentive or do we have to educate them or is it all of those?"

"How do we affect the behaviour of groups of people that may be as small as a hockey team or as big as a whole country, a nation, around hockey?"

"It's starting to get there. We've made little steps in advancing it, but we still have a long ways to go."