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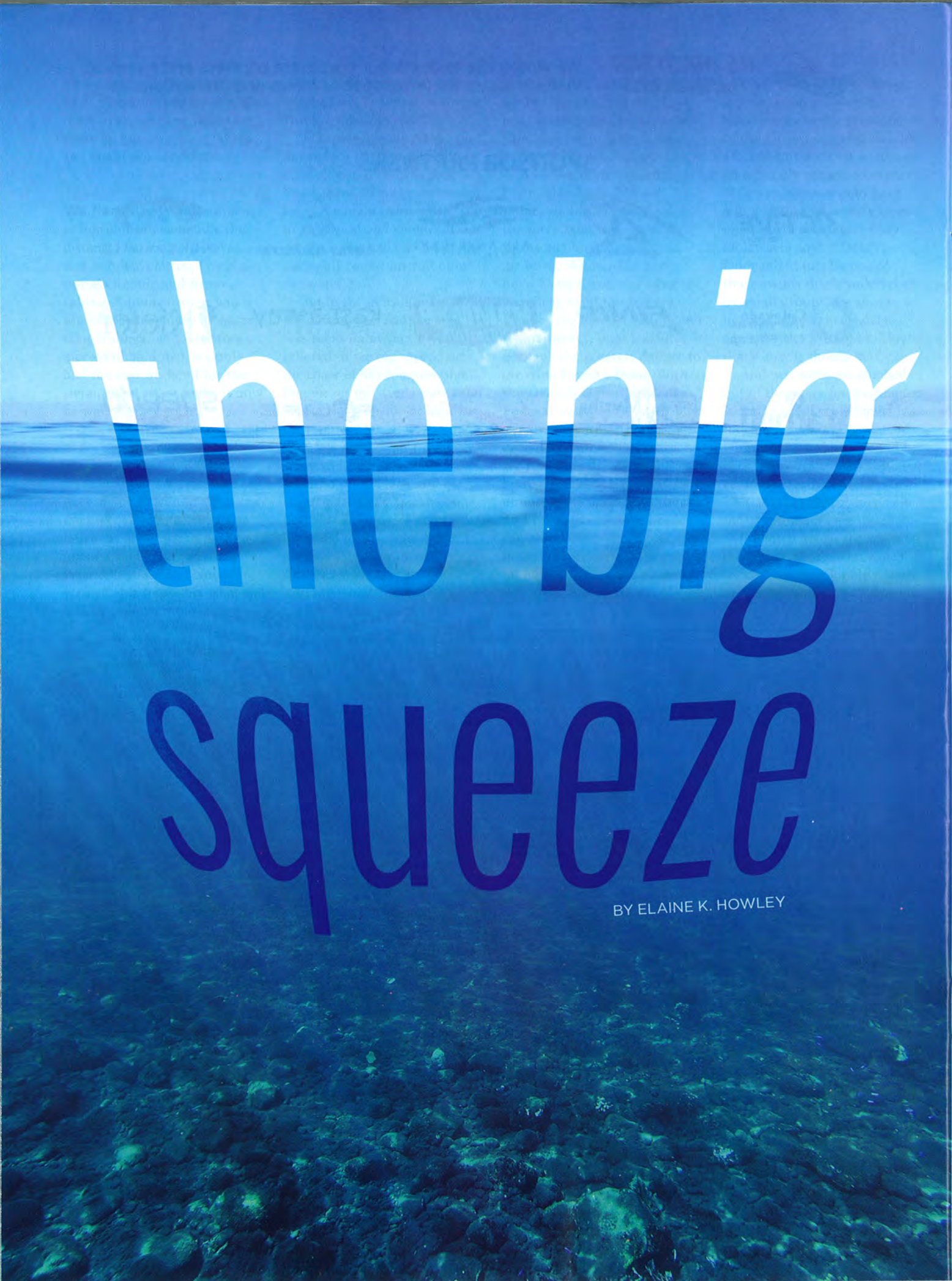


the big squeeze

BY ELAINE K. HOWLEY

A scary lung condition is leaving some athletes gasping for air.

For an experienced triathlete like Montreal-based Katherine Calder-Becker, the 2007 Mooseman Triathlon, a half-Iron distance event, should have been a walk in the park. A practiced open water swimmer who had grown up a competitive pool swimmer, Calder-Becker was never concerned about the 1.2-mile swim in scenic Newfound Lake as she donned her wetsuit and toed the line with some 2,000 other competitors. But within minutes, her whole world changed.

"About 10 or 15 minutes into the swim, I started to struggle," she says of the day she first suffered swimming-induced pulmonary edema, a deleterious interaction of blood and lungs that can cause major trouble for those who experience it.

"The sensation was like I was going to drown," she says. "I'm a strong swimmer and always have been, so it was really weird. I couldn't get my breath. It was very scary."

Dog paddle and backstroke didn't help as Calder-Becker's breathing grew raspy and a strong cough rose up, the body's instinctive attempt to clear the misplaced fluids that had breached the blood-air barrier in her lungs.

With each attempt to continue swimming, Calder-Becker's coughing grew worse and her fear increased. A long struggle later, she arrived on land "wheezing and coughing and white and shivery and cold, and I didn't know what it was."

But she kept going. That's the endurance athlete's credo, isn't it? Just keep going.

She got on her bike and pedaled along coughing and gasping. She finished the bike portion of the race, and dazed, started trying to run. "I couldn't. I grabbed onto a tree in transition and luckily there was a nurse there." The nurse volunteer prevented Calder-Becker from continuing and took her to an ambulance where EMT staff were puzzled by her symptoms. "They discovered that my blood oxygen levels were low, but they didn't know what was happening."

Calder-Becker's husband was also competing at the event, and after finishing he was directed to the ambulance where she was resting. No longer feeling the panicky, oxygen-starved sensation as strongly, Calder-Becker didn't want to go to the hospital. Unaware of how potentially dangerous her condition was, the medical staff released Calder-Becker. But she was plagued by this unexplained, terrifying episode and sought advice from her family doctor.

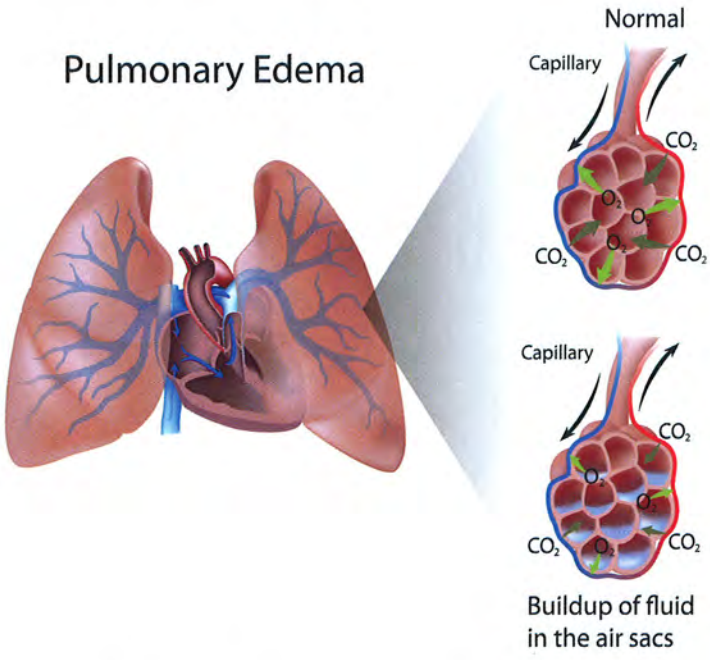
"We did a bunch of chest X-rays and breathing exercises looking for asthma and he talked to a bunch of other doctors. He didn't know what it was either, but he thought it might have been acid reflux," Calder-Becker recalls. They tinkered with her diet and added an antacid pill, hoping that would solve the problem, and Calder-Becker resumed her training and racing regimen. After working with her doctor for a few weeks, Calder-Becker's confidence returned. "I felt good training, so we thought we'd figured it out." She felt ready and healthy to tackle the next big challenge on her summer racing schedule, Ironman Lake Placid.

"Race day came, and off I went, and again, at the top of the swim in Mirror Lake, maybe about three-quarters of a mile into the swim, that same sensation that I can't breathe came on. It's this tightness in your neck and the back of your knees. And you're thinking, 'If I can just loosen the wetsuit, I'll be able to breathe.'" She unzipped her wetsuit and soon a kayaker noticed her struggling. He stayed with her, and somehow, impossibly, she managed to complete the whole 2.4-mile swim course after 2 hours and 20 minutes, more than double the time she had anticipated being in the water.

Calder-Becker met a nurse and doctor in the transition area who told her to take a few deep breaths and try to clear her lungs. "They asked me to cough into a Gatorade cup and it was pink and red." The nurse wondered what Calder-Becker might have eaten that was red, but nothing fit the bill.

Coughing up pink, foamy sputum is never a good thing, so the concerned doctor tested Calder-Becker's blood-oxygen saturation and found it perilously low at 63 percent, she says. At that level, the possibility that Calder-Becker's heart could have become unstable was frighteningly high. For healthy, nonsmoking adults, normal blood-oxygen levels range from 95 to 100 percent. Calder-Becker was rushed to the nearest emergency room.

Once at the hospital, chest X-rays showed no sign of cardiac injury, but excessive fluid in her lungs. She was administered Lasix, a diuretic that flushed the fluids from her body, and her breathing and blood-oxygen levels improved quickly. A close call, but Calder-Becker had nearly suffocated in a flood of her own blood that had breached the walls of the millions of tiny capillaries that line the



inside of the lungs and transfer oxygenated blood back out to all corners of the body.

Search for Answers

Because of the excellent care and quick thinking of volunteer and medical staff at the Lake Placid event, Calder-Becker finally had the beginnings of an answer—a diagnosis of SIPE. Pulmonary edema is an abnormal accumulation of fluids in the lungs that makes breathing difficult. It's typically diagnosed in older patients with other heart issues such as leaky heart valves or a weak left ventricle. It's not the sort of problem a fit athlete like Calder-Becker should have encountered while participating in a triathlon.

"Pulmonary edema is a very bad thing in an otherwise healthy person," says Dr. Charles C. Miller III, professor of biomedical sciences at the Graduate School of Biomedical Sciences at Texas Tech University Health Sciences Center in El Paso. Also an avid triathlete and runner, Miller had his own encounter with SIPE in 2001 after an aquajogging session that followed a particularly difficult weekend of training leading up to the Berlin Marathon.

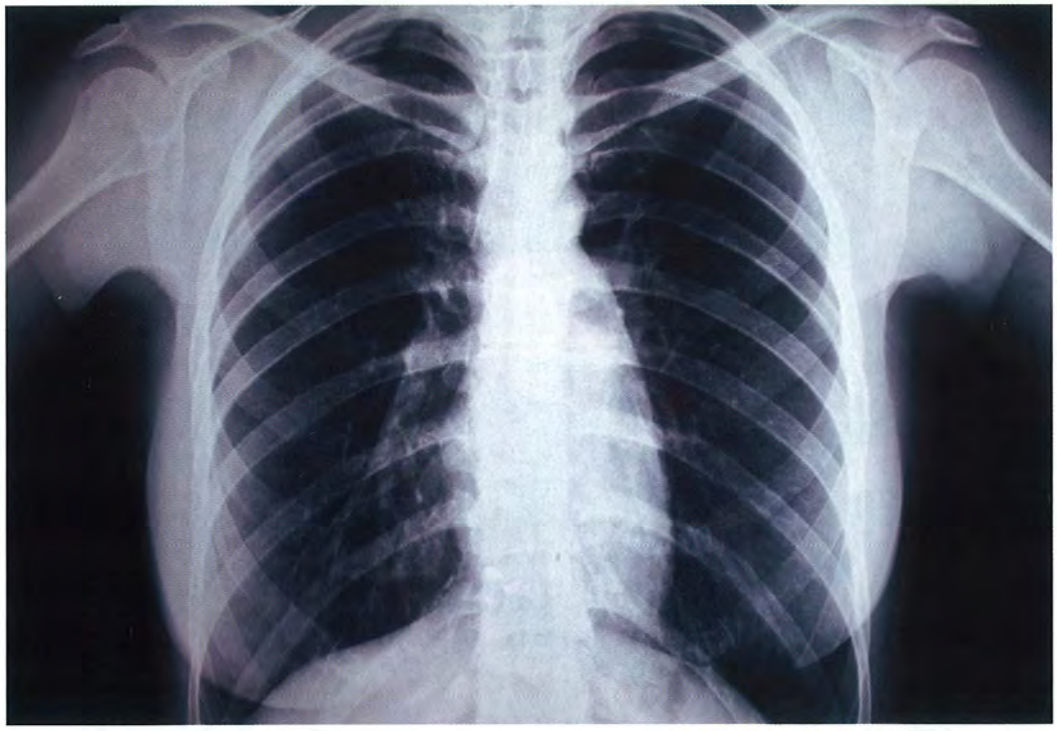
Miller's own experience with SIPE, a single incident that nevertheless launched a new aspect of his research science career, eventually led him to collaborate with Calder-Becker in investigating this rare condition. Miller's SIPE experience included the same demand for oxygen unequal to the level of exertion, but Miller's training as a cardiovascular epidemiologist meant he understood the danger of coughing up pink, frothy sputum and sought immediate medical attention.

Though he knew he'd experienced pulmonary edema, Miller was unable to explain why. At the time of the episode, he was a healthy 40-something athlete, peaking in his training in advance of a big endurance event. His medical team was able to rule out a heart attack and also determined that Miller had no contributing structural abnormality in his heart. "It was pretty clear there wasn't anything terrible going on," he says. "But still, pulmonary edema in an otherwise healthy person, we're trained to believe that's a very bad thing."

An Ounce of Prevention...

Though studies are ongoing, several factors appear to contribute to incidences of SIPE in triathletes. Making a few small changes may help prevent suffering another bout of SIPE.

1. **Visit your doctor.** If you think you may have had a bout of SIPE, talk to your doctor. Miller suspects a connection with hypertension, an all-too-common problem for many Americans, but one that's relatively easy to treat and manage. Adding an ACE II inhibitor can help lower blood pressure, which is good for a number of reasons, not just preventing SIPE. Dr. Richard Moon notes that if you experience shortness of breath during a race you should go to an emergency room and get a chest X-ray to determine if it's SIPE. "Nail down the diagnosis, and secondly, go to a physician for various tests to rule out some of the [other] causes [of pulmonary edema] like coronary artery disease or heart valve disease."
2. **Cautiously hydrate before a race.** Common prerace wisdom dictates that endurance athletes should drink as much as they can in advance of a big event to help prevent dehydration over the course of the race. But for some athletes, that can be too much of a good thing. Adding a liter or two of water to an already high volume of plasma can put additional stress on the body and increase the likelihood of SIPE, Miller says. "For a triathlete, you can always make up any deficit on the bike. For a swimmer, I would recommend that they should be well hydrated, but don't hyperhydrate."
3. **Start slow and easy.** Where Calder-Becker once hammered from the start to capitalize on her strongest leg of the triathlon, she now starts at the back or edge of the pack and takes her time starting, particularly if she hasn't been able to warm up enough before the race. "Let everybody go, and then start at the back," she says. "I start slow and build, and once I know I'm beyond the first kilometer and I feel confident that I'll be OK, I start speeding up and catching people."
4. **Acclimate to conditions.** Cold water also appears linked to the incidence of SIPE. In colder water (anything below the normal human body temperature of 98.6 degrees F is considered cold for these purposes) the capillaries in the extremities constrict to shunt warm blood to the core to maintain vital organ function. This can mean even more fluid in the chest.
5. **Listen to your body.** If you are suddenly gasping for air disproportionately to the effort being exerted at any point in a race, something is wrong. It might be an asthma attack, an allergy, a panic attack, SIPE, or something else. Any of those conditions could be dangerous, so "get out of the water and live to fight another day," Miller says.
6. **Get a wetsuit that fits.** "We weren't able to separate the effect [of the wetsuit in our study] because everyone wears a wetsuit in wetsuit-eligible swims, but I do think the extrinsic compression of the wetsuit is important symptomatically," Miller says. And it makes sense: If you stand around for an hour before the race in a too-tight wetsuit, you're adding pressure to an already overloaded system and the compression of the neoprene could be forcing blood into the chest where it may later seep into the lungs. Take that tight system and put it in water, and the pressure increases yet again. Miller and Calder-Becker both recommend DeSoto Sport's T1 two-piece wetsuits for athletes with body types that don't match the standard one-piece suit silhouette.



X-Ray of Healthy Lungs

X-Ray of Lungs with Pulmonary Edema

Kept overnight for observation, Miller recovered quickly. Within a few days, he was back to normal, though he says his lungs "still felt sore, like someone had scrubbed them with a bottle brush." But he resumed training, his runner's low heart rate thumping along steadily as if nothing had happened. "I found it very annoying that I couldn't figure out what was going on."

Miller delved into the limited research that had been published about immersion pulmonary edema, a variant of SIPE that occurs in scuba and free divers and has been documented by the Navy in combat swimmers and rescue divers. "Most of the case reports were done in military swimmers—Navy SEALs and Israeli marine commandos—and it seemed to be largely associated with periods of intense dryland training that involve cross-training in the water."

Based on the literature, Miller began to form a hypothesis: Pressure.

Under Pressure

When runners and cyclists and other dryland athletes train, one of the first ways the body becomes more efficient is by producing more blood to help deliver oxygen to the working muscles. This plasma volume expansion is what causes an athlete's resting heart rate to drop over time, as the heart can deliver more oxygenated blood with each beat. Could this increase in plasma volume be somehow forcing fluid into the lungs?

In conjunction with this increased volume of fluid cruising around the body, that a number of other factors must also contribute to incidence of SIPE, Miller posited, or else every runner who ever jumped into the water would get SIPE. And since SIPE seems to be largely relegated to triathletes and athletes who undertake most of their training on land, not people who swim primarily, there must be some difference between how the body reacts to swimming training and dryland training.

To begin testing his theories, Miller, who had connected with Calder-Becker via an online triathlete forum, designed an online survey in conjunction with USA Triathlon to try to determine the rate of incidence and causes of SIPE among the organization's membership.

Conducted in 2008 and published in 2009, the USAT study showed that 1.4 percent of USAT members had experienced SIPE. A few correlations emerged between risk factors and episodes of SIPE, and many of the survey's findings point to pressure as a catalyst.

Constrictive pressure from the water, adrenaline, throngs of competitors surging forward at the start, a too-tight

wetsuit, and even one's own blood in the form of hypertension can all contribute to the incidence of SIPE, the survey indicated.

Other risk factors include overhydration before the start, inadequate warm-up before the beginning of the event, even possibly mega-doses of fish oil supplements. "The fish oil thing surprised me," Miller says; this finding that resulted in a swirl of potentially unwarranted media attention. Though the USAT study did turn up some evidence of a link between fish oil supplements and SIPE, Miller says they were casting a wide net, and a repeated finding or additional study would be required for a stronger connection to be made.

Another ongoing study investigating immersion pulmonary edema funded by the U.S. Navy and helmed by Dr. Richard Moon, professor of anesthesiology, professor of medicine at Duke University School of Medicine, has taken a more invasive approach to search for answers.

His study is looking at the mechanism driving immersion pulmonary edema and SIPE and how to predict and avoid the condition by inserting cardiac catheters into study participants, submerging them, and having them exercise while the instruments gather data. Though the study's findings have not yet been released, early indications point to higher-than-average pulmonary artery pressure being a factor in SIPE.

Moon is also investigating whether the addition of the drug sildenafil—marketed as Viagra—may help reduce incidence of IPE. "Viagra relaxes smooth muscle in blood vessels and is used to lower pulmonary artery pressure in people who have pulmonary artery hypertension. We reasoned that if it's true that people who have IPE have higher pulmonary artery pressures during immersed exercise, then it may be a useful drug to lower it in these people, so that's why we started testing it."

In addition, Moon is looking for a possible genetic component to the condition, which may help explain why, under the same conditions, most people are absolutely fine and only a few will experience IPE. Miller agrees there's probably a genetic piece to this and thinks the origins of his own SIPE experience could stem from a family history of heart failure and hypertension. "How your heart handles high cardiac output, is related to this, and I think there's an element

Donate Yourself to Science

Want to help doctors find answers to the mystery of SIPE? Dr. Moon's Navy-funded study at Duke University is moving into a new, less-invasive phase and is seeking participants. "The newer phase is to find out exactly why pulmonary artery pressure is higher in IPE-susceptible people," he says, and they need athletes who've experienced SIPE to help solve this question. This study will observe participants' EKG and MRI readings while they are riding a submerged exercise bike to test Moon's theory that a stiff left ventricle could contribute to an increase in pressure during the filling phase of the heartbeat.

If you'd like to take part, contact Moon at ipedivestudy@duke.edu. Moon also urges physicians with questions about IPE to contact him for more information.

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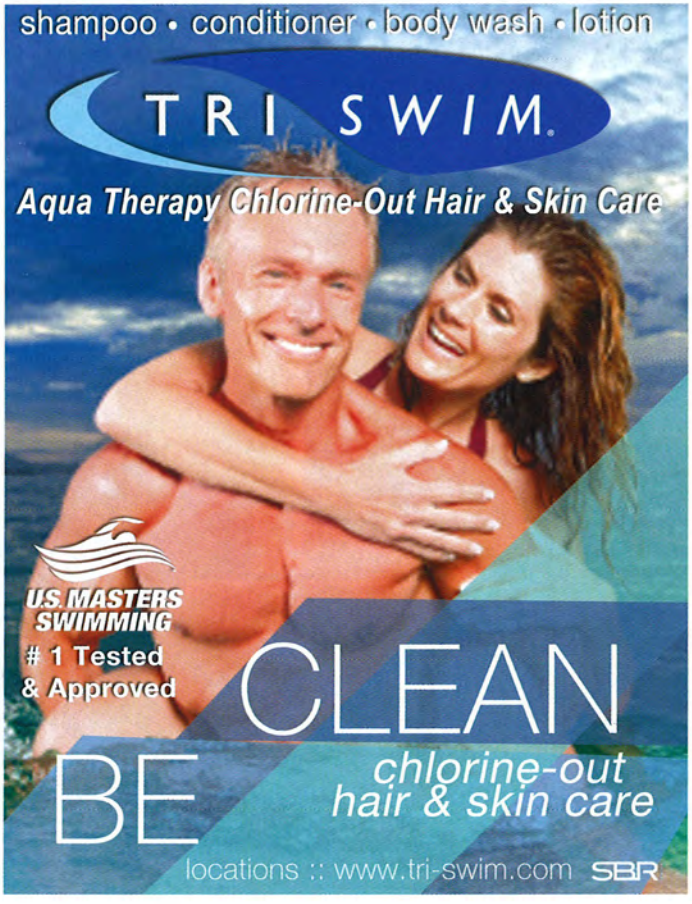
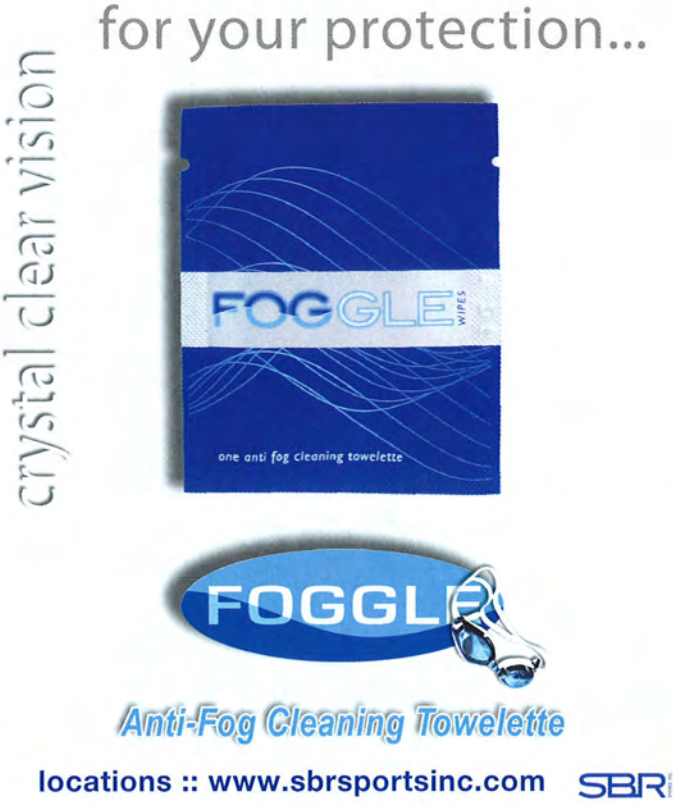
of genetic susceptibility in there somewhere."

The Good News

The good news about SIPE is that once you've gotten out of the water and stopped exercising, the condition usually corrects itself in time. In severe cases, oxygen and a diuretic can provide dramatic improvement. Most SIPE sufferers report a tender feeling in their lungs for several days after an episode, but are usually able to return to normal training and racing activities within a week. An episode of SIPE may also help identify other underlying problems that require treatment, resulting in improved health in the long run.

SIPE is scary, but with more awareness comes safer races. If race directors, volunteers, and athletes know the recognizable symptoms of SIPE, they're more likely to spot them and act. Increased awareness also means more research is likely, and breakthroughs as the result of Moon's and other studies could be right around the corner.

For Calder-Becker, her journey with SIPE has reinforced her love of triathlon and provided her a means to help others.

"The first doctor I reached out to about this told me to stop doing triathlons. But that was the wrong answer," she says. A few days later, she spoke to another doctor who told her, "'Don't let anyone tell you to stop. Find the answer.' So I decided I wasn't going to let anyone take away what I love. I need to find the answer, if not just for me, then for everyone else who might be having this problem. I'm really bound and determined to try to figure it out or at least put the information out there. We're making progress, and it's perseverance that's gotten us to this point." **S**