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### The Autopsy that Changed American Sports: Dr. Bennett Omalu and the Story of CTE

Dr. Johnson:

This is a Clinician's Roundtable on ReachMD, and I am Dr. Shira Johnson. With me today is Dr. Bennet Omalu. Dr. Omalu is a forensic pathologist and neuropathologist, and he holds multiple other degrees and board certifications including a Master's of Public Health and Epidemiology - University of Pittsburgh, and an MBA from the Tepper School of Business at Carnegie Mellon University. He was the first to discover and publish findings of CTE, chronic traumatic encephalopathy, in American football players. The book *Concussion*, which was based on his work, was published in 2015 and later adapted into a film of the same name.

Today we're discussing CTE, which has been diagnosed on autopsies that were performed on NFL players as well as other professional athletes.

Dr. Omalu, welcome to the program.

Dr. Omalu:

Thank you so much for having me, Dr. Johnson. I'm glad to be here.

Dr. Johnson:

There is so much we can talk about, but let's start out by telling us how you were led to your discovery of CTE while performing autopsies?

Dr. Omalu:

Well, what happened, I was in Pittsburgh 3 months outside my training and fellowship as a neuropathologist, so you may say that I was still very academically hot. I was still in very good command of the literature. So, I did an autopsy on Mike Webster, and prior to his death he had manifested a constellation of symptoms, and he had been labeled with a variety of diagnoses, including bipolar disorder, schizophrenia, depression. But I had grown up in Nigeria, I had no understanding of football. I did not know what football was, but one thing I recognized was that they wore helmets to play football, and the presence of helmets in my opinion meant there was a risk of brain injury or head injury while playing football. So, in my training as a neuropathologist and also as a forensic pathologist, I realized I had read literature that stated that when human beings are exposed to repeated blows of the head, there is a risk of permanent brain injury. In fact, there was this big paper that was published in 1969 by the Royal Colleges of Medicine of London, Dr. Roberts, where they found out that in boxers there is a risk of permanent brain damage, and it was called dementia pugilistica. The risk of brain damage in boxing was published as far back as the late 19th Century in Europe, and then in 1928, Dr. Martland, a forensic pathologist in New Jersey, labeled it punch drunk syndrome. So it was well established that boxers would suffer permanent brain damage. We thought in the literature then that it was a primary amyloid, meaning it was almost like Alzheimer's disease. So I knew that, and I wondered if that could occur in boxers, why wouldn't it occur in football players, especially in somebody like Mike Webster, who had played for 17 years and in my calculation had received hundreds of thousands of blows to his head over the years? And as a forensic pathologist, I knew that when you suffer brain trauma, you could manifest a constellation of progressive mood disorders, even neurological symptoms ranging from Parkinsonism to ALS symptoms to frank neuropsychiatric disorders, so I chose to save his brain. Although his brain appeared normal on CT scan, on MRI—and even on the autopsy table, his brain looked relatively okay—so I was very puzzled why wouldn't his brain show any abnormality by naked eye examination?

And again, I must emphasize there were some unique attributes about myself. I was dealing with depression. I was not married, I was in my 30s, so I had time on my hands. I was making a good salary, I wasn't spending it, so I spent my own money to examine his brain out of personal curiosity, and it led me to this discovery. So, when I saw it, I showed the findings to 2 other doctors just to confirm what I was

seeing. I reviewed the literature as far back as 400 BC to the time of Hippocrates. As I'm talking to you now, there are some books that are over 400, 500 years old I had to buy on brain trauma, and I discovered that it had never been reported before, that this was something new that I was dealing with. It was obviously not Alzheimer's disease or frontal temporal dementia or any known dementia, and it was not an amyloid like we thought dementia pugilistica would have.

So, the next thing was to give it a name before publishing it, but in the United States legal system, there is what is called a Daubert principle, Daubert in law, and it means scientific evidence cannot be admitted in the court of law unless it has precedence and unless it falls within the generally accepted principles of medicine. As a forensic pathologist, I knew this was an occupational (inaudible 6:23) and in a matter of time it will end up in the court of law, so I couldn't give it any name I wanted—because I was tempted to name it Mike Webster's Disease. I was tempted to call it football dementia or dementia footballitica, but I couldn't because there was no precedence for all these names. So I went back again to the literature looking for names already existing in the literature. I saw names like traumatic encephalitis. I saw names like neurosis, traumatic neurosis. I came across chronic traumatic brain injury syndrome. I came across traumatic encephalopathy. Then I came across chronic traumatic encephalopathy. I liked chronic traumatic encephalopathy because it had a good acronym, CTE, and I think it sounded sophisticated.

(Laughter)

Dr. Omalu:

So, I love CTE. I published it. And people in sports medicine have said to me, "Look, Bennet, CTE is one of the most successful branding efforts in the history of medicine." Think about it. Fifteen years ago you Google CTE, if you get 1 or 2 hits, you'll be lucky. Today Google CTE, you will get hundreds and thousands of hits. Even my 7-year-old son knows what CTE stands for, and his classmates in school. So I'm happy that we are where we are today, but something that I find very discouraging, we are becoming too obsessed and fascinated with CTE, forgetting that CTE is only one disease in a spectrum of diseases. People still suffer other types of brain trauma and brain damage from blows to the head with or without CTE. I must emphasize that CTE is part of a spectrum. It's only one disease. You may still have brain damage without having CTE. People and doctors need to know that.

Dr. Johnson:

Can you explain to our listeners how the autopsy findings correlated with the clinical pathology that you just described to us?

Dr. Omalu:

Yes. As doctors, we know that we always perform clinical pathologic correlation, meaning if you have a prevailing planimetrics and then you have prevailing evidentiary autopsy findings, you probably—based on the generally accepted principles of medicine, you can correspond on much the clinical symptomatology with the pathological findings. So, in this day and age, what we are finding is when you suffer a blow to your head with or without a helmet, your brain suffers two types of acceleration-deceleration injuries, the linear acceleration-deceleration injury, which is benign or more benign, and then the angular rotational acceleration-deceleration, which is when the brain rotates around its midline. Angular rotational acceleration-deceleration is more dangerous than linear acceleration-deceleration. And when you suffer angular rotational acceleration-deceleration, the parts of your brain that are exposed to the largest amounts of energy and shearing forces are the midsagittal structures and the periventricular structures. Guess what? In CTE, that is what we are observing, that parts of the brain that have the largest amounts and densities of protein. The periventricular, parasagittal, midsagittal structures are most exposed to the shearing forces from the midbrain to the amygdala to the paraventricular hypothalamus, the pulvinar, the globus pallidus. Okay? So, and in addition to that, the part of your brain that is most exposed to linear acceleration shearing forces is your midbrain. That is the midbrain that now connects the brain stem to the cerebral hemispheres. So, CTE is indicating that all these parasagittal structures are the parts of the brain that are first and most damaged by acceleration-deceleration injuries, and they are the ones per unit density of brain tissue that would manifest damage earlier. And what do the parasagittal structures do from your midbrain to your mesiotemporal lobe to your limbic system? They control your mood, and that is why we see one of the first symptoms of brain damage CTE is a mood disorder. They begin to manifest disinhibition, violent tendencies, depression. Then as that goes on, it begins to involve the new cortical structures, and as they get older, they now begin to manifest cognitive symptoms. So, what we are seeing in pathology by clinical pathology correlation, is confirming what we have observed clinically. But people need to know that the accumulation of proteins is a late-phase of the disease. Primarily, the disease is a white matter disease, is an axonal or cytoskeletal disease. So, in addition to the accumulation of proteins, you have white matter lesions. You have accumulation of damage in the white matter. You have vascular components, vascular injuries. You have an increased incidence of stroke, okay? And also, you may have posttraumatic epilepsy or posttraumatic encephalopathy in situations where you have focalized damage of brain tissue. So, this is larger than CTE as a distinctive disease of itself. This is why recently some people are beginning to introduce the terminology traumatic encephalopathy syndromes, which I think is a more appropriate terminology.

Dr. Johnson:

If you are just joining this discussion, this is ReachMD, and I am Dr. Shira Johnson. I am speaking today with Dr. Bennet Omalu, forensic pathologist from UC Davis California. We're talking about CTE, chronic traumatic encephalopathy, as diagnosed in professional athletes.

Dr. Johnson:

Yes, it's interesting, because if you agree with me, up until that time, until your work, the general feeling of the American community was that the changes we saw in football players and other professional athletes were psychosocial as opposed to any clinical pathology. We weren't aware of the changes that were going on in their brain, and we thought it was the lifestyle that they were living, the situation that they were in. Is that correct?

Dr. Omalu:

Yes, and again, because conventional CT scans and conventional MRIs will turn out negative. So doctors were generally—this is not the statement of accusation or what—but we had this conformational thinking in the medical industry, and for some reason, as a collective group we ignored the established and published literature, even beginning as far back as the time of Hippocrates, because it was Hippocrates that actually described concussions. He called it *contusio cerebri*. And when I researched the literature over the centuries, it was something very well established, but even a human being receives one violent blow to the head or several violent blows or multiple minor blows to the head and it can result in brain damage is something very well established. And, in fact, in 1957, the American Academy of Pediatrics published a position paper in the *Pennsylvania Medical Society Journal* that no child under the age of 12 in America should play football, boxing or wrestling. I'm not kidding when I discovered that paper, I couldn't believe it, but in America, even we doctors collectively, we choose to ignore the science. And if you read my book, *Truth Doesn't Have a Side*, I describe this phenomenon so much, because I did not understand why a foreigner like myself who did not know anything about football would come to America and discover something so pertinent about America's most popular sport and America's richest league. That is very illustrative of a unique sociological phenomenon that is going on, but I'm glad, I'm glad we have evolved now. We are beginning to manifest the scientific principles we have always known.

Dr. Johnson:

But it was your absolute objectivity that you didn't have a knowledge of football from your country that led you to really see the entire picture with clearer eyes than maybe, perhaps, our physicians or our community were seeing.

Dr. Omalu:

Yes. You know, what happened, some of the criticisms I received in the past by very prominent doctors, is that Omalu is not a known, established name in science. It does not belong to an Ivy League university or a major, established research program, so he is an outsider that should not be trusted. But when you look at it critically and objectively, what was actually my strength that these established names thought was my weakness was the fact that I was an outlier. I was an outsider. I was naïve of the phenomenon of football. So, without me knowing it, I did not conform to the expected way of thinking surrounding football. I was being objective. I was being scientifically objective. I was thinking clearly without any implicit bias, because people have said to me, including doctors, that, "Bennet, if you had grown up in this country, if you had grown up watching football, there was no way you would have opened up the body of Mike Webster." And I actually went back to research. Autopsies on football players was a rarity. It was not commonplace to find autopsies of retired football players because we held them in so much awe and reverence that forensic pathologists, medical examiners and coroners wouldn't even touch their bodies because it was deemed some level of desecration. In fact, that day I did the autopsy, everybody was asking me why I was opening him up. We knew why he died. He had a massive heart attack. But I was thinking further. I was wondering why would such a man of such acclaim become a drug addict, become homeless and live off his truck? That just did not match in my head. That wasn't what normal people would do, and there was no well-established history of neuropsychiatric illness in his family. And so, I guess, that's why I travel across the world and give talks. We need to encourage diversity. We need to bring in people who are different in whatever we do, because they are bringing a totally new perspective that we ourselves may not be aware of. Diversity in whatever dimension is a good thing. That is an asset.

My thanks to our guest today, Dr. Bennet Omalu. We've been discussing CTE, chronic traumatic encephalopathy. Dr. Omalu, it was a pleasure having you on the program today.

Dr. Omalu:

Thank you so much. Thank you for having me.

Dr. Johnson:

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