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WHIPLASH / NECK PAIN

Accident Reconstruction: a View from the Barricades

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In a previous editorial ("Is There an Engineer in the House? Or, The Sound of the One Eye Winking," *Dynamic Chiropractic*, January 27, 1997), I discussed an accident reconstruction (AR) case that I had reviewed and provided some ideas for rebuttal. Based on the huge response generated by that piece, I've decided to take another look at the art and science of AR, this time with the goal of outlining specific things to look for in such a report.

Having used the term AR, I should point out that most of the work currently provided to insurance companies by ARs are not really reconstructions of the rigorous kind. For the most part, they take the form of theoretical reconstructions based (more than anything else) upon a string of assumptions which, for practical reasons, are largely untestable.

In the ideal world, an AR is hired some time after an accident, but before the involved vehicles are repaired or demolished.

The AR is also provided with scaled accident drawings outlining measured skid marks, roadway debris, splatter marks, etc. Photographs of the crash scene are also available. Medical reports or autopsy reports may be available as well. Armed with this information, published crash data, and his/her knowledge of physics, the AR can now provide a meaningful estimation of crash information. Yes, even with all of this, all we can do is provide an estimation or range of probable values.

We should define "low speed" collisions as reflecting only the differential speed of the vehicles involved (e.g., a stationary car struck at 8 mph and a car travelling at 60 mph struck by a car travelling in the same colinear direction at 68 mph are both examples of low speed collisions). In most cases of low speed rear impact collisions, police reports are not made. When they are, rarely is any of the information reliable in estimating collision speeds or acceleration forces. By the time the AR is hired, damaged vehicles have since been repaired, rendering the vehicle inspection a pointless exercise. In cases where no repairs were made, if a long time has elapsed between the time of the accident and the time of the inspection, any apparent damage to bumpers or other structures cannot be reliably attributed to the accident in question.

In lieu of actual vehicle inspection, most ARs are provided with low quality (e.g., Polaroid) photographs of the external parts of the involved vehicles, often with limited views and often of only one of the involved vehicles. In my experience, it is rare that photographs of the bumper struts or isolators are provided. Quite often, the treating doctor's bills and other records are provided to the AR. From this limited information, many ARs will generate surprisingly (read that questionably) precise figures for collision speeds, delta Vs (change in velocity), and acceleration forces. From this, they will usually conclude that occupant injury was either likely or not likely.

Here are a number of general things to look for in AR reports followed by a short explanation of each:

1. Reported delta V and acceleration figures are given as the "worst case scenario."

As an AR, I was taught to provide a range of probable figures based on the imprecise nature of these reconstructions, a subject that is, mercifully, beyond the scope of this editorial. We might estimate a collision speed range of 2-9 mph, for example. Since the occupant's acceleration is then estimated from the calculated delta V, we are also forced to provide a range of acceleration. One method of determining acceleration is to divide the delta V (in feet per second) by the duration of that change (in seconds). Using a collision speed range of 2-9 mph, we might estimate the range of delta V (of the struck car) to be 1-6 mph (depending on the relative sizes of vehicles involved and other factors), and the corresponding acceleration to be 0.4-2.3g. (Multiply 6 mph by 1.47 to get 8.82 fps. Divide this by 0.120 seconds, the typical duration of such a crash, and you get 73.5 fps^2; divide this by 32.2 fps^2 to get the value in g.)

When you look at the range of variation between 0.4 and 2.3g (a 475% difference), the lack of precision of such work becomes painfully obvious and is, therefore, not likely to be terribly persuasive as a legal argument. To sidestep this problem, many ARs have devised a clever solution: they report only the larger of the two figures as the "worst case scenario" so that the reader never sees the lower figure and, thus, has no idea of the breadth of the potential uncertainty of the calculations.

2. Reported delta V and acceleration figures are averages.

Since the purpose of these reports is to determine whether or not the occupants could have been injured, it would be most reasonable to determine the peak loads experienced by them. Unfortunately, the equation given above (a=delta V/t) provides us only with an average acceleration of the vehicle. And, while we figured an acceleration of 2.3g in a 6 mph delta V above, full scale crash tests using human volunteers under those same conditions have reported peak linear accelerations to the heads of the volunteers of more than 12g. This is not surprising, since Severy's early work in the 1950s demonstrated such disparities between occupant and vehicle accelerations.

ARs frequently quote these recent studies as producing no permanent injury to the volunteers, but rarely mention these acceleration figures. And, of course, the key word is "permanent;" most of the published crash tests have produced transient injuries at a delta of 5 mph, a figure that the authors rightly concluded is probably the threshold of soft tissue injury. And, I might add, this would be the threshold only for adult healthy male volunteers, ideally positioned, and anticipating an impact.

3. Reported delta V and acceleration figures are the same for the occupant as for the vehicle.

Most commonly, only a single set of figures is reported, leaving the reader to wonder whether the figures apply to the vehicle or the occupant or both. Quite unlike the higher speed collisions where vehicle damage is significant, in low speed collisions damage can be quite minor. Many newer cars are equipped with 5 mph rated bumpers. When two cars equipped with these bumpers collide at 10 mph, there may be no appreciable damage. However, because the lead car is not fixed in space, the compression of these bumpers is not entirely plastic, and energy is transmitted to the occupants nevertheless. Several studies have been conducted at low speeds and it's been shown that the threshold for crush damage to most passenger cars in rear impact collisions is an 8-12 mph impact speed. And, in two of the more critically acclaimed crash studies - those usually relied upon by insurance company expert witnesses - the cars underwent multiple collisions at 10 mph (5 mph delta Vs) without material failure. In addition to making my point here, the astute reader will also extract from this the shattering of a very popular myth: no crash, no cash. Essentially, we have a soft tissue injury threshold occurring often just before the damage threshold to the vehicle is met.

Since little damage occurs at low speeds, we can say that the collisions are somewhat elastic in nature. Or, the coefficient of restitution (e) - a ratio of the after-collision velocity differences and the pre-collision velocity differences - is high. In a perfectly elastic collision, e is -1 and in a perfectly plastic collision e is 0. Most passenger car seat backs have a coefficient of restitution of -0.3 and impart an additional delta V of 30% to the forward moving occupant. Thus, when a vehicle delta V of 6 mph is estimated, we would estimate the occupant's delta V to be about 7.8 mph.

4. No vehicle inspection took place.

The potential problem with this is fairly self-evident. With inspection of the vehicle, we could see any resulting damage first hand and measure it directly. This will almost always allow a more meaningful and credible analysis.

5. No repair invoices were examined.

This should also be considered somewhat curious if the timing is such that the AR is hired late in the case by an attorney representing an insurance company (or by the company itself) that has already paid for the repairs and would certainly have access to those documents. I suspect that, in order to influence the report, these documents are sometimes purposely withheld. Many times, however, repair invoices can be used by the plaintiff to discredit the AR report or impeach his/her testimony in court, particularly when the repairs were fairly extensive and the AR had assumed a lack of damage based solely on provided photographs or hearsay.

6. References to existing research or data were vague and nonspecific.

It's quite common for ARs to make vague reference to "a large body of research" or "several published studies," etc., that support a particular theory. They don't often provide the full citations. In my experience, experts tend to quote rather selectively from the literature, citing, for example, one fact that fortifies their opinion, while ignoring another which might conflict with it. The best defense against this is to request the full citation so that you or the patient's attorney can get a hard copy of it.

Much of this material is very dated, some of it going back into the 1960s. Other citations are to editorial or anecdotal material lacking any scientific foundation. Several of the more popular papers attempt to compare whiplash injuries to everyday activities such as sneezing or plopping into chairs. These comparisons are entirely without physiological or physical merit and can easily be exposed as nothing more than specious and silly examples of industrially inspired junk science. The authors apparently have no formal training in physics. In truth, the largest body of valid scientific evidence fully supports and explains the connection between low speed collisions and soft tissue injury.

7. No calculations were provided.

This is another red flag. In a real AR report, the AR will typically provide several pages of calculations so that an AR hired by the opposing side can determine whether the proper assumptions were made and whether the calculations were accurate and derived using appropriate equations. No "black box" calculations should ever be accepted blindly by either side. Although some ARs pad the report with pages of extraneous material relating to punctilious vehicle specifications -- apparently as a contrivance to provide the appearance of exactitude - this type of information frequently adds nothing to the report and is rarely used in any of the calculations. Conversely, ARs should always be willing, upon request, to provide a table of the equations used, the coefficients for variables, sources of raw data, and all assumptions made during the analysis (coefficients of friction in the roadway, distances between vehicles, reaction times, etc.).

8. ARs argue that head restraints, seat belts, or bumper isolators reduce the risk of injury to negligible levels.

This is simply not true. At best, head restraints reduce the risk of injury in whiplash by about 11-20%. Last year, the Insurance Institute for Highway Safety rated only 3% of head restraints in the 160 or so cars tested as "good." On the other hand, there is an enormous body of literature that shows, unequivocally, that seat belts and shoulder harnesses increase the risk of cervical spine injury significantly in low speed collisions. And the small body of literature relating to bumper isolator performance in low speed rear impact collisions suggests that they provide no important measure of protection to occupants.

9. Estimates made of speeds or distances rely on one witness or other nebulous information (stroke of isolators, lack of damage to cars, photos, etc.).

Low speed crashes are devilishly difficult to quantify due to many of the uncertainties mentioned earlier. Because cars are designed to perform in required crash tests of higher speeds, they are relatively stiff at low speeds, and impacts of under 8 mph frequently do not leave any measurable telltale damage with which to estimate energy loss. It is also difficult to accurately gauge the amount of energy loss to the friction of tires and brakes or to the ground - factors that can be reasonably ignored in reconstructions of higher speed collisions.

For this reason, ARs frequently base calculations on distances before and after impact. In a false start type of impact, for example, where both drivers begin to move forward from a stop and the lead vehicle then stops suddenly and is struck from the rear by the driver behind, the initial distance between the two cars can be used to estimate the impact speed. To do that, we must also estimate the rear driver's acceleration. Using an average passenger car acceleration of 4.8 fps2, and estimating the original distance between cars at 8 ft, we calculate an impact speed of 6 mph. However, if the driver takes more of a jackrabbit start and the distance is more like 20 ft, we might calculate an impact speed of 12 mph or more. Needless to say, the person who is in the best position of estimating that distance was not paying sufficient attention to avoid the accident in the first place and, thus, cannot be considered entirely reliable.

In other cases, the stroke of the bumper isolators has been used to estimate the collision speed. However, in addition to the potential error associated with late examination of the vehicle, many isolators do not leave stroke marks, while slightly offset collisions may result in nonlinear and unreliable motion of these isolators. This leaves the method imprecise at best and, at worst, roughly the equivalent of reading tea leaves. And, if the isolators were never examined, a skillful attorney might well ask the AR whether they might even have been frozen, i.e., nonfunctional, and if so, whether the dynamics of the collision might have been different. Either way, it is a difficult question to answer, but at least serves the purpose of exploiting the degree of uncertainty inherent in the AR's science.

With any assumptions made - whether they be roadway coefficient of friction, closing or after-collision distances, or acceleration rates of false start collisions - a careful cross-examining attorney would not only ask how and why those values were selected, but would inquire as to the possible ranges of these values. This would be followed by having the AR recalculate the figures based on the extremes of these ranges in order to further exploit the degree of uncertainty imminent in these reconstructions.

10. The AR concludes that the probability of occupant injury was minimal.

This is, of course, the bottom line and is precisely what the insurance company or defense attorney wants to hear. It ultimately becomes the *prima facie* pretext to withhold further treatment of the allegedly injured parties and to reject medical bills as unnecessary. From a pure point of logic, the argument is almost humorous unless, of course, you consider the patient to be dishonest and unreliable. Then the AR becomes, essentially, a polygraph test. If injuries are unlikely and the occupant claims to be injured, he/she must be dishonest. The chief argument against this ploy is the doctor's records. They will usually clearly support a valid injury and stand on their own merit. The reasonableness of ongoing care is substantiated through careful SOAP note documentation and with published guidelines, where available. Nevertheless, a skillful attorney can further underpin the credibility of the AR on cross-examination.

First, the AR should describe his/her training. Frequently, we find that biomechanical engineers studied sports physiology or designed prosthetic knees during their training and know very little about whiplash. Other ARs have bachelor level degrees or are retired police officers. Their understanding of human anatomy and physiology is not particularly comprehensive. They could also be asked about the numerous outcome studies that have been reported or the epidemiological studies demonstrating a clear link between low speed collisions and injuries. Then they could be asked about the various risk factors for injury that have been identified and reported and whether they considered them in their probability estimates. It goes without saying that they would be asked whether they have any clinical experience or whether they have ever examined a patient; or this patient for that matter.

Finally, if I were an attorney, after I finished all of these (and other) questions, I think I would ask the AR if he/she had ever known of a case where one occupant was injured (or killed) while another occupant was not: everybody has, so the question is rhetorical. Then I'd ask whether he/she really thought that the risk of injury for any particular person could be reliably estimated on the basis of speed and acceleration alone, even if the figures for delta V and acceleration were known with certainty. Even a "yes" answer would not sound very convincing at that point.

Parting Comment One of the newest strategies to be devised by defense lawyers is to attempt to disallow testimony by chiropractors based on the fact that they are neither biomechanical engineers nor ARs. Accordingly, some DCs have become certified in AR. If you are interested in learning about becoming an AR (several courses are offered around the country), drop me a line (by e-mail) and I'll send you more information.

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