

**COURTROOM MEDICINE
VOLUMES 11 AND 11A
CHEST, HEART AND LUNGS**

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A. I just can't answer you; I don't have the data.

Q. Do you have your notes here?

A. No. I did not bring them.

Counsel for State Insurance Fund: Your Honor, I have no further questions.

COMMENT: This questioning is a further attempt to establish that a symptom attributed to asthma could just as likely have been caused by claimant's episodes of hard crying as from her meat wrapping work. Unfortunately counsel was not able to fully develop this interesting argument since the doctor apparently did not bring his notes or the other indicated data with him. It is important for counsel to have all medical records, reports, and notes subpoenaed before the trial, so as not to leave it to chance that the witness will bring au his records. Whenever possible subpoenas should be ordered by the court so that sanctions can be imposed for failure to comply.

§ 1.80 Case No. 8—Lung Damage Caused by Exposure to Toluene Diisocyanate (TDI) *

§ 1.81 Facts of the Case

Robert Hill brought an action against his employer, Santa Fe Railroad under the Federal Employers' Liability Act (FELA) for lung injuries sustained as a result of exposure to toluene diisocyanate (TDI).

Among his duties for the railroad, Mr. Hill spray-painted the interior of hopper railroad cars (used for transporting foodstuff) with epoxy paints and a urethane coating which acted as a sealer. The urethane coating contained TDI, a chemical which is unsafe at levels greater than .02 parts per million. The concentration of TDI during the painting operation could reach as high as 8,000 times the recommended ceiling. To counter the possible danger from exposure to TDI, Santa Fe supplied Hill with a plastic air hood and a respirator.

The plaintiff painted 20 to 30 hopper cars from late 1976 to June 1977. When he began to paint these cars more frequently,

* Transcript was provided through the courtesy of C. Marshall Friedman, P.C. Counsel for Plaintiff was C. Marshall Friedman, Esq. of St. Louis, Missouri.

he began to suffer from sore lungs. Paint would enter the plastic hood and Mr. Hill would use vaseline to remove the paint from his face, neck, and nose. He would also take the hood off to blow paint out of his nose and cough it up from his throat. He became ill while inspecting a railroad car in June 1977 and did not work thereafter.

The trial court entered judgment on a jury verdict for \$600,000. The State Supreme Court affirmed the judgment, despite the defendant's contention that the verdict was excessive. The court held that there was evidence that the plaintiff suffered permanent lung damage as a result of exposure to TDI, would incur substantial medical expenses in the future, was permanently disabled, and was in constant pain and suffering.

§ 1.82 Direct Examination of Plaintiffs Lung Specialist**(1) Qualifications**

Q. Doctor, would you please state your full name?

A. Craig William Bolton.

Q. And you are a medical doctor?

A. Yes.

Q. Duly licensed to practice in the State of Missouri?

A. Yes.

Q. Of what medical school are you a graduate, doctor?

A. Dusquene University.

Q. In what year?

A. 1968.

Q. Would you, for the benefit of the ladies and gentlemen of the Jury, outline your post-graduate training and experience?

- A. I graduated from medical school in 1968 and then took what's called a straight medical internship at the University of Wisconsin from 1968 to 1969. The next two years were spent in internal medicine residency. Following that I took an additional thirteen months specialty training in chest diseases completing my program then in August of 1972.

(2) Definitions of Internal Medicine and Pulmonary Functions

- Q. Following the completion—by the way, with respect to your specialty, the work in internal medicine as opposed to the chest and pulmonary, could you tell us what internal medicine is and what the subspecialty with respect to pulmonary function is?

Some people consider internal medicine or internists as diagnosticians. They look at the total body, problems involved with the GI tract, the blood, the heart, the lungs. You can then go on and take a specialty within that field such as again, the heart, the lungs, and I opted to take a specialty interest in the lungs or pulmonary disease, the breathing tubes, pneumonia, lungs, what have you. Also in my internal medicine residency I had an additional five months training in lung disease before I decided to go on and specialize in it.

(3) Additional Training and Experience as Pulmonary Specialist

- Q. Could you tell us what was involved in this special training and your additional training in pulmonary work with reference to the lungs?
- A. The additional special training basically had a threefold aspect. The first was to evaluate lung service, outline the treatment program. Secondly, it was to do consultative work, other services within the university hospital, such as the surgical evaluation of a patient who had lung disease. And then lastly was working in the pulmonary function lab and writing papers, research.

COMMENT: The jury's first impression of the witness is favorable. Plaintiff's attorney succeeds in having the doctor highlight his impressive background in the field of lung or pulmonary work, with special emphasis on his additional training in treating pulmonary disease.

The defense attorney will often try to stipulate to the witness's qualifications, rather than let the witness continue to build one impressive credential upon another. Plaintiff's counsel should always resist such a tactic.

- Q. Following your training, could you describe what additional work and training you then underwent?
- A. At the completion of my training I then had a military obligation and spent two years at

the U.S. Army Hospital at Fort Bragg, North Carolina. During that time I was the Chief of the Pulmonary Service there in the Pulmonary Function Lab and my last year there was spent running the immunization clinic.

Q. Would you describe what was involved in being the Chief of the Pulmonary Clinic at Fort Bragg, North Carolina?

A. Being Chief of the Pulmonary Clinic meant that I looked first of aid at the patients who had lung disease, whether they were active duty military personnel, dependents or retirees. Secondly, I was involved in reading all the pulmonary function studies or the breathing tests that were there at the hospital in the allergy clinic. My responsibility was two-fold. It was also the immunization clinic for active duty personnel that would be going overseas to make sure that they had current immunization status and had no untoward effects to the immunization program. The second aspect of it was evaluating patients who had allergic difficulties.

(4) Private Practice and Affiliation With Two Hospitals

Q. And upon completion of your tour of duty, did you then enter into the private practice?

A. Yes.

Q. And that was at Appleton, Missouri?

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A. Yes.

Q. When did you begin practicing in Appleton, Missouri?

A. August of 1974.

Q. And in the last five or six years have you limited your work to primarily the pulmonary patient and the pulmonary work?

A. Yes.

Q. At Appleton, Missouri are you affiliated and a member of the staff of the hospital at Appleton?

A. I'm on the active staff at the Memorial Medical Center which is a 700-bed hospital and on the courtesy staff at St. Joseph's Hospital which is also a 700-bed hospital.

Q. And at the present time are you undertaking or are you going to undertake a position at Memorial Medical Center?

A. As of tomorrow, if I get back in time, I will assume the position of Chief of Staff of that hospital.

Q. And you will be Chief of Staff?

A. Of the Memorial Medical Center.

Q. Prior to that did you have a title and position with respect to the Department of Medicine?

A. For two years I was Chief of Medicine at that institution.

Q. Two years you were Chief of Medicine?

A. Yes.

COMMENT: This witness will certainly impress a jury. There is no doubt that he is a specialist in the pulmonary area. The jurors will listen carefully to what he has to say and will afford his testimony great weight. Plaintiffs are not always fortunate to have a doctor with as many qualifications as this witness. When counsel does have such a witness he should take full advantage of it, as was done in this case, with an in-depth recitation of the doctor's experience in the field.

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Q. And are you also on the staff, do you have a relationship with the University of Kansas at Kansas City?

A. I am a clinical instructor at the University of Kansas, Kansas City School of Medicine. They rotate students down for pulmonary experience.

(5) Board Certification in Pulmonary Disease: Procedure for Certification Explained

Q. Doctor, are there boards and do you obtain certifications as a physician within your specialty?

A. Yes.

Q. What is board certification, what's involved in that respect?

A. Board certification for internal medicine means that you have taken the prescribed program of internal medicine at an approved hospital and then sit and take examinations for two days. To become board certified in your specialty area, as I am in pulmonary disease, you have to first complete your internal medicine program, pass the internal medicine boards, fulfill the educational requirements for eligibility for your subspecialty

and then again sit and take the examinations.

Q. And have you successfully completed and have you been board certified as an expert in pulmonary disease?

A. Yes.

(6) Certification in Internal Medicine

Q. And have you also been board certified in internal medicine?

A. Yes.

Q. You have been certified in both internal medicine and the subspecialty of pulmonary disease?

A. Yes.

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(7) Affiliation with Medical Organizations

Q. With which medical organizations within your specialty are you affiliated?

A. Within the specialty of chest medicine, there are two medical organizations. One is the American Thoracic Society and the other is the American College of Chest Physicians. I belong to both. Within the internal medicine organization the major one is the American College of Physicians and I am a member of that organization.

(8) Familiarity with Toluene Diisocyanate or TDI

Q. Doctor, in the course of your experience have you had occasion to become familiar with TDI or toluene diisocyanate?

A. Yes.

Q. And have you had occasion to treat individuals who have developed lung and respiratory injury or damage as a result of exposure to or inhalation of TDI?

A. Yes.

Q. How far back does your experience with TDI go?

A. My recollection of my first experience would have been when I was an intern on the chest service in 1968 and 1969.

Q. Over the years have you seen a number of patients who have developed pulmonary injuries or pulmonary problems as a result of exposure to toluene diisocyanate?

A. Yes.

COMMENT: The attorney elicits testimony that the physician's first experience with TDI goes back to his service as an intern. In addition to using this testimony to show the physician's many years of experience in the field, the attorney is implicitly saying to the jury that the link between TDI and lung disease has long been established and therefore the defendant-employer must or should have had notice of the dangers of TDI. Counsel implies that Santa Fe should have known of the link between TDI and lung.

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disease despite the fact that it is generally not permissible to impute knowledge by the medical profession to an employer, absent evidence that the employer has the information in his own files. Later, counsel succeeds in again implying notice by the employer, when the witness cites various publications by the medical community and the federal government describing the link between TDI and lung disease.

(9) Publications on TDI

Q. Have you had occasion in the course of your training to research and become familiar with the medical literature with respect to that type of injury and problem?

A. Yes, I have.

Q. And can you tell us with respect to your research when did the literature first include information with respect to TDI and the pulmonary lung and respiratory problems as a result of exposure to or inhalation of that chemical?

A. The initial reports were published in Germany. Then shortly after World War II the German experience was published in the late '40s. The European and the United States literature began to show this entity in the 1950s and finally in about 1962 a major series was reported in the United States literature of two hundred twenty-two cases involving individuals exposed to TDI. Since then there's just been continued publication of problems associated with this agent as far as the lungs are concerned.

Q. Have you become familiar with the publications and literature with respect to this type of injury and problem?

A. Yes.

Q. Doctor, I'll hand you what has been previously marked Plaintiff's Exhibit 16 and 32 through 36. Would you look at these articles and tell us whether you have had occasion to become familiar with those particular articles that have been published on the toxicity

and the injuries and lung problems as a result of exposure to and inhalation of TDI?

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A. Yes.

Q. Those go back to the sixties, is that correct?

A. Yes. The earlier one here is 1962, the Massachusetts experience.

COMMENT: Right from the start, the jury is confronted with the fact that Toluene diisocyanate, as a cause of pulmonary disease, has been documented probably since World War II and most definitely since the 1960s.

(10) Studies Described in Literature with Respect to the Effect of TDI on Animals

Q. Are there also included among those, the literature, is there experience with respect to tests that have been done on animals concerning TDI?

A. Yes.

Q. What is the significance of the animal studies in its relationship and with respect to the effects of TDI?

A. The animal studies demonstrate experimentally the changes that take place in the trachea or the wind pipe in the small breathing tubes upon exposure to TDJ which include the production of fibrosis or scar tissue which will impede the flow of oxygen back and forth from the air sac into the blood and also obliteration of the small breathing tubes which would impede air flow and cause inflammation and irritation throughout the tracheal and bronchial tubes.

Q. Is there a relationship and of what significance is the fact of this obliteration which in experimental animals developed lung damage and lung—

Defendant's Counsel: Your Honor, I object to counsel leading the witness.

The Court: Sustained as to the form.

(By Plaintiff's Counsel)

Q. What is the significance of these types of pulmonary and respiratory problems in experimental animals?

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- A. Animals are traditionally used for research because obviously you would not want to expose a human being to the concentrations that produce toxicity and animals then are called animal models of disease that can be seen in human beings.

(11) Authoritative Publications in Field of Pulmonary Problems

(At this point the reporter marked documents Plaintiff's Exhibits 52 through 57 for purposes of identification.)

(The following took place at the side bar, out of the hearing of the jury.)

The Court: Mr. Friedman, what is the purpose of these exhibits?

Plaintiff's Counsel: To have them identified by the physician as being authoritative publications in the field, that they were available and authoritative on the subject of toluene diisocyanate, respiratory and lung problems, and that they were published in the early fifties and sixties.

The Court: You will not read from them or he won't?

Plaintiff's Counsel: I don't intend to go into any of the details with this witness, merely to qualify them as properly authoritative and available in the event I need to utilize them later in the case.

Defendant's Counsel: If he'll be asked questions about them, about each one specifically, I will still object to them.

The Court: I will allow him to state the general thing that he is aware of and then stop right there, merely to establish the question of knowledge.

(Proceedings returned to open court.)

(By Plaintiff's Counsel)

- Q. Doctor, with respect to the earlier exhibits 16 and 31 through 36, are those all authoritative publications?

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- A. Yes. In fact two of them are from the New England Journal of Medicine which is probably considered the foremost publication in medicine in the United States, if not the world.

- Q. Well recognized within the medical community?
- A. Very much so. In fact, I would estimate that probably eighty-five percent of the physicians subscribe to the New England Journal of Medicine.

(12) Articles on Relationship Between TDI and Respiratory and Pulmonary Problems

- Q. And all of these articles contain information with respect to the respiratory and pulmonary problems as a result of exposure or inhalation of TDI?
- A. Yes.
- Q. Handing you now what has been marked Plaintiff's Exhibits 52 through 57, could you tell us whether these articles are published and available and well-recognized and authoritative publications?
- A. The first one was published in 1956 on asthmatic syndrome following exposure to TDI in Industrial Medicine and Surgery which is
- Q. Is that a well-recognized and authoritative publication?
- A. It is a recognized and authoritative journal. The second one that I have here—
- Q. That's 53?
- A. Exhibit 53 is in the British Journal of Industrial Medicine, a recognized journal, on changes in lung function. The next two, which would be exhibits 54 and 55, are the proceedings of the Royal Society of Medicine, a very well recognized journal. Exhibit 56 and 57 again from the British Journal of Industrial Medicine.
- Q. And all of these, are these examples of the type of publications that were available with respect to the toxic lung problems as a result of exposure to TDI?

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- A. Yes.
- Q. And they are all well-recognized and authoritative sources, is that correct?
- A. Yes. III might interject, there are really two ways that one can check the medical literature. There is a publication called Index Medicus which lists all the medical publications in the world and one can simply find a title by going to that and pulling out the articles that have been written. The second one is one called Current Contents which comes out weekly and publishes the face sheets of all the medical journals that are being published that month. In addition, it will give it by title, by author and by subject matter.

So one can very easily go into the literature and review and find out what information is available.

- Q. And, Doctor, as a physician in this field have you also become familiar with the publication of the Federal Government NIOSH on the Occupational lung and respiratory problems as a result of exposure to TDI?

COMMENT: The attorney gives added credence to plaintiff's case, by making special mention of a federal publication that exclusively focuses on the link between toluene diisocyanate (or TDI) and lung disease. Once it becomes clear that the federal government as well as respected scientific publications recognize the link between toluene diisocyanate and lung disease, the jury can easily determine that the plaintiff's lung problems in this case are attributable to TDI.

- A. Yes, I'm on the NIOSH mailing list.

- Q. All you do is write them and they send you the publication when it comes out?

- A. Some of them there is a charge for.

- Q. Such as those that have been marked Plaintiff's Exhibit 24, the 1973 publication?

- A. Yes.

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(13) Effect of Till on Lungs and Respiratory System

- Q. Doctor, could you explain to us how TDI affects the lung and pulmonary and respiratory systems?

- A. TDI is an irritant that has specific effects upon the mucous membranes of the body, and those would include the eyes, the nasal passages, the sinuses, the tracheal-bronchial tract. It affects you basically to increase the amount of secretions that are present, and in the case of the bronchial tube, spasm of the muscles that surround the bronchial tree, and produces difficulties with breathing, wheezing and coughing and shortness of breath.

- Q. What is it about the lungs and respiratory system when we take a breath of air, what happens to the air that we breathe in and how is it affected by the effects of TDI in the respiratory system such as Robert Hill's.

- A. The purpose of the lungs is basically to bring oxygen from the air into the body and exchange it into the blood and to eliminate carbon dioxide which is a waste product of metabolism that we exhale as a gas. Many people think that kidneys are the main mechanism for controlling our waste on a day-to-day basis. But indeed, it's really the

lungs. The ratio would be that the lungs excrete twenty-five thousand milligrams of what's called acid, where the kidneys only excrete eighty milligrams. So you can see that the lungs play a major part in the excretion of waste. So it's oxygen in, carbon dioxide out. In order to do this we have a system of passages, the respiratory system, which really starts with the nose; we inhale the air through the nose, it goes into the back of the throat to the pharynx, into the wind pipe or the trachea, the bronchial tree or the bronchi and then on down to the air sacs. The easiest way to envision the lung system is to actually think of a tree, the wind pipe would be the trunk of the tree, the bronchial tubes would be the main branches of the tree, the bronchioles or the small breathing tubes would be like the stems on the tree, and then the air sacs which is where the actual exchange of these gases takes place would be like the

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leaves on the tree. Any evidence or area of obstruction throughout the breathing tube would, of course, lead to impairment and deficiencies in the gas exchange.

COMMENT: The witness is very impressive. His testimony is well thought out, and he explains the technical medical concepts in language readily understandable to the lay juror.

Q. Is that what occurs from the effects of TDI?

A. The effects of TDI will interfere with the normal exchange of air in and out of the lungs through the two mechanisms. There are specialized cells that line the breathing tubes called goblet cells or mucous cells. I think most everybody has had a cold that's settled in your chest and you cough up sputum. That's because the cells have been producing more secretions. The irritation from the TDI will cause these cells to make more secretions which then lodge in the breathing tubes. In addition, the breathing tubes are surrounded by smooth muscle on the outside of the breathing tubes, and when irritated by the TDI, these go into spasm or constrict so that the bronchial tree is narrowed. Again we'll have problems then with narrowing the breathing tubes and increased secretion which leads to the shortness of breath, cough, sputum, wheezing.

(14) Opinion that Plaintiff's Problems Attributable to TDI

Q. Is that what has occurred with Robert Hill?

A. Yes.

Q. Now, Doctor, when the breathing tubes are obstructed or narrowed, what happens when we breathe in air and what happens when we expel air or try to get the waste out, what happens within the body?

A. Probably the easier way to explain it is the sensation of strangulating. If you were to choke somebody he's going to become very apprehensive; he's going to work much harder at breathing. His respiratory rate will increase and his pulse rate will increase.

Associated with this can

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be sweating, turning blue or cyanosis, paleness to the skin, and as this gets worse, the individual becomes more apprehensive, increases the work of breathing which leads to more strain by both the lung system and upon the heart. One of the major difficulties with people who have lung disease, TDI or asthma or bronchitis, is that the harder you try to work at breathing, to force your air out, that is the least efficient way of moving air out of the body, and people normally tend, to try to breathe harder and faster and that's not an efficient exchange mechanism. What you need to do is to take a very slow deep breath and blow it out as slowly as you can. But when you're apprehensive, concerned about the difficulty of getting air, it's hard to put mind over matter in that situation.

Q. Are these the effects that you observed in Robert Hill?

A. Yes.

Q. As a result of the TDI?

A. Yes.

(15) Diagram of Respiratory System

(At this point reporter marked document Plaintiff Exhibit 58 for purposes of identification.)

Q. Doctor we've had marked Plaintiff's Exhibit 58. Would you step up and describe for us if you could—stand on this side so the court reporter can hear you—describe for us what is shown on that exhibit and what part of the respiratory system or anatomy that is?

A. This basically is a diagram of what I just explained about the air passages in the respiratory system. We have here the passage in the back of the mouth, obviously the passage is coming through the nose, goes to the posterior pharynx and into the larynx or the voice box situated right here. Air then passes through the larynx or the voice box, into the trachea or the wind pipe, again that would be like the trunk of the tree. On the right side there are three lobes to the lung, an upper,

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a middle and a lower lobe, and there are breathing tubes or bronchi that go to each one of these lobes. The left side, which is demonstrated with the lung stripped away, shows the breathing tubes to the left. Now there are only two lobes to the left side, an upper and a lower lobe. These breathing tubes are like initially the big branches of the tree and they continue to divide into smaller and smaller branches called bronchioles as evidenced by this line. Now the bronchioles are only two millimeters, which is extremely small. If we start with this big first division, by the time we get out to the bronchioles there has been

in the neighborhood of twenty-seven divisions. Ultimately we get to the air sacs which would be like a sponge-like material totally enclosing all these breathing tubes. Now again, the purpose of this is to bring air into the air sacs for oxygen exchange across the air sacs, carbon dioxide which is coming in the blood which is bathing the lungs exchanges into the air sacs and then we exhale it. The breathing tubes also are surrounded by cartilage in the breathing tubes which give some support as far as the bronchial tree is concerned. There's also smooth muscle that is wrapped around the bronchial tree, each bronchus, sort of like an elastic band. Irritation to that will cause the band to tighten, which will then, of course, make the lumen or the internal diameter smaller. The lung is so large that if we were to open this up and cut each little air sac, you could cover a football field with the amount of tissue that is present within the lungs.

COMMENT: Notice that a diagram is used by the witness in explaining the complex medical information. When dealing with a complex situation, it is important to use diagrams and other types of demonstrative evidence to assist the jury in their understanding of the case. If such a diagram was not used, counsel runs the risk of the jurors not understanding the doctor, becoming bored and not paying attention. This can happen even with the best witness, when the technical explanations are long and involved

Q. Doctor, when we breathe, does the oxygen actually go through and into all of the bronchi or the—

A. Yes. The distribution is, of course, throughout the breathing tubes ultimately getting to the business end, which are the air sacs. Now it should be pointed out

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whether we're in the upright position or lying down makes a difference in terms of distribution of air flow. In the upright position there's preferential distribution down to the lower parts of the lung.

(16) Reiteration of Effects of TDI on Respiratory System

Q. What effects do TDI or toluene diisocyanate have upon this respiratory system?

A. Again the two major effects that it has are that the cells that line the inner part of the breathing tube, which are really not depicted here, swell, increases the amount of secretions which can lead to obstruction anywhere along the breathing tubes. And in addition, the smooth muscle that surrounds the breathing tubes that we described as an elastic band will tighten and constrict so the lumen or the opening then of the breathing tube is smaller which increases the work of breathing.

Q. Is this actually a clogging up effects?

A. The clogging up occurs with the secretions. The narrowing occurs with the spasm of the

smooth muscle.

Q. Could you give us an example, another example, of what the effect is and how this has affected the breathing system?

A. Perhaps one way to look at it would be the tubes are the pipes that drain your house from the toilet for instance, perhaps not a pleasant analogy, but if you have your stool here and everything is working all right and you flush the toilet and the water is going to go on out to the pipes, then connect to the sewer in the street. And you have a tree, for instance, whose roots are grown into your pipe in the house, you're going to have a problem with movement of the water out of the stool or from the sink because it's clogged, and this is a somewhat similar analogy. You'd have trouble with movement of air into and out of the lungs for the same reason. It is being clogged and it's more narrow.

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COMMENT: In explaining a technical concept, it is a good idea to analogize it to something the jurors can relate to. The example used in this case was somewhat dangerous, however. The jurors could have found the discussion of a toilet to be vulgar, and might have been turned off by the analogy. Although the analogy did not seem to harm the outcome in this case, it may be prudent for counsel to caution witnesses about the types of analogies they should make.

Q. Is that what's happened to Robert Hill?

A. Yes.

(17) Description of Small and Large Breathing Tubes

Q. And with Robert has it affected all of the tubes, both the large breathing tubes as well as the small bronchioles that you described?

A. Yes.

Q. It has affected both, is that correct?

A. Both.

COMMENT: Counsel brings out the fact that the plaintiff has suffered damage to both his large breathing tubes as well as the small bronchioles of his breathing tubes. The extent of plaintiff's damage will obviously affect the amount of the ultimate award.

Q. Now, Doctor, -with respect to the resistance, in - other words, if you breathe, if you're trying to get the air into your system or into the air sacs and if you have the obstruction or the narrowing and you have this resistance, what does the body do to try to compensate for this?

- A. To begin with these breathing tubes can be divided up basically into two types, large breathing tubes and small breathing tubes. Small breathing tubes are sometimes called the peripheral airways. The larger breathing tubes are those that are above the two millimeters in diameter that we talked about, and the smaller breathing tubes would be less than two millimeters in diameter. It has been recognized over the last fourteen, fifteen years that the site of resistance to air flow, that the movement of air into and out of the lungs, primarily

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occurs in the smaller breathing tubes and that frequently individuals will have problems within the small breathing tubes by their pulmonary function studies and show very minimal function and changes as far as the large tubes are concerned. In general, when people are coughing and bringing up sputum, that is arising from within the large tubes. Individuals who have obstructions to their small airways, this is demonstrated by studies of what is called frequency dependency of compliance. Compliance is change in the volume of anything, in this case air that is being moved into a system associated with change in pressure, that is the amount of pressure necessary to move that volume of air into the lungs. Individuals who have trouble with compliance means that it takes much greater pressure that they have to generate to move the same amount of air volume into the lungs. Now frequency dependency of compliance is a test that is demonstrated by obstruction to the small airways, and when that occurs, it means that as the individual breathes harder and his rate increases, his frequency of breathing or their rate increases, his compliance becomes worse so it requires more pressure to try to move the same volume of air into the lungs. So that then if you have an individual who is increasing his respiratory rate, it's taking much greater pressure to move the same volume of air into the lungs.

(18) Tests Measuring Obstruction in Small Breathing Tubes

- Q. What is the test called that measures the obstruction in the small breathing tubes?
- A. Basically three tests that could be done to measure obstruction. The first is what we talked about, the frequency dependency of compliance which is a really complicated test involving a person swallowing a balloon, and secondly, there are lung volume tests, and the third is the measurement of the mid-expiratory flow rates on pulmonary function studies called the spirometry. The correlation is that back in the later sixties and early seventies, people recognized that this more difficult

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test called the frequency dependency of compliance test did measure the small airways and then noted the correlation of these mid-expiratory flow rates on a single breath test and these were measuring the same things. So one can look at the simple tests, the spirometry and the lung volume tests and obtain the same information. So the simple tests

correlate to the more complicated tests which demonstrate obstruction to flow in the small airways.

Q. Is that the FEF 25/75?

A. Yes, that's the FEF 25/75.

Q. And have you obtained those tests over the years that Robert has been a patient of yours?

A. Yes.

Q. Have you obtained those tests this year in 1982?

A. Yes.

Q. And could you just summarize for us what those tests have indicated?

A. He has consistently shown severe reduction in flow through the small breathing tubes, thirty-five, forty percent of normal.

Q. Let's assume that just the week before last the tests done at St. Mary's Hospital in Larson City, those continued to show thirty-four percent.

A. I would assume that they would show obstruction to the small airways. This has been a finding that has been consistent in Mr. Hill since 1977.

Q. And by thirty-four percent, a hundred percent would be full?

A. Would be normal.

Q. And thirty-four percent would be about a third of the potential?

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A. Yes.

Q. And if the person would go less than that to zero, would he be dead?

A. Right. What you would say is that an individual that had FEF 25/75, that's the mid-portion of the spirogram demonstrating obstruction to the small airways would be expected to have difficulties with breathing continuously with any kind of exercise. I think you should all recognize that when we do any kind of activity we have two things that have to happen. We increase our pulse rate and we increase our respiratory rate both as an attempt to provide adequate oxygen to the tissues of the body, so that an individual that has obstruction to the small airways and he tries or she tries to increase her respiratory rate in a normal physiologic response to the body, he's going to have

tremendous problems with shortness of breath.

(19) Cause of Plaintiffs Cough, Wheezes, and Loss of Breath

Q. Could you tell us, Doctor, when Robert is sitting in the courtroom, what's causing him to cough, what causes the cough and the loss of breath under such circumstances?

COMMENT: In essence, counsel is telling the jurors: "If you don't believe or understand what the doctor is saying, judge for yourself; the plaintiff is right here." Counsel's job in proving damages is made easier, since the jurors can observe the plaintiff's actual and continuing struggle for breath.

A. That is primarily due to the secretions accumulating in the large breathing tubes as opposed to the small breathing tubes.

Q. What causes the wheezes, what are the wheezes?

A. Wheezes are high pitch musical sounds that are associated with obstruction to the large breathing tubes usually because of spasm of the smooth muscles.

Q. And have you observed those wheezes, are they also called rhonchi?

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A. That is the noise that is produced by a partial obstruction within the breathing tube, for instance by a big glob of mucous that needed to be coughed out.

Q. And have you observed wheezes and rhonchi in Robert Hill's breathing tubes over the last five to six years since you've been treating him?

A. Only once have I ever found him not to have these noises. He has consistently had them. Including the present time?

A. Yes, I walked over about a block and a half with Mr. Hill this morning.

Q. From my office?

A. From your office.

Q. Half a block?

A. During that time he became extremely short of breath. He had audible wheezing without the aid of a stethoscope.

Q. What do you mean by audible?

A. I did not need to have a stethoscope to hear him. You could hear him from me to the jury.

Q. And difficulty in breathing?

A. Yes.

Q. What causes that, Doctor?

A. I believe that he was having progressive spasm of the bronchial tree and irritation to those cells that line it to produce sputum.

Q. And has that resulted from his exposure to TDI?

A. Yes, I believe this is the result.

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(20) Bronchospasm as an Effect of TDI

Q. Doctor, one other thing I want to cover. You indicated the two effects of the TDI, one being the development of the secretions in the bronchial tree, the second being the bronchospasm.

Q. What causes the bronchospasm within the system?

A. Again the bronchospasm is that the smooth muscles that are like those elastic bands around the breathing tubes, when stimulated or irritated, constrict down just as though you were pulling a rubber band tight. That produces the bronchospasm and wheezing.

(21) Plaintiff's History

Q. You may have a seat, Doctor. Doctor, when did you first have occasion to see Robert Hill?

A. Mr. Hill was first seen by me in 1977 at the time of admission to Memorial Medical Center.

COMMENT: It is important that this witness be established as plaintiff's treating physician. Because his credentials are so spectacular, the fact that he took the plaintiff as a patient may underscore the severity of the illness. Additionally, if the doctor merely saw plaintiff once, for purposes of testifying, on cross examination opposing counsel could question his ability to speak about all aspects of the plaintiff's illness. In this case, opposing counsel will have no means with which to challenge the doctor's familiarity with all aspects of plaintiff's medical condition.

Q. At the time of his original hospitalization?

A. Yes.

Q. Were you called in as a specialist in pulmonary medicine to examine and treat him?

A. Yes.

Q. And did Mr. Hill remain under your care throughout the entire course of his hospitalization?

A. Yes.

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Q. And has he remained under your care since his discharge?

A. Yes.

Q. Is he your patient?

A. Yes.

Q. Have you seen him and treated him and become knowledgeable with respect to Robert Hill and his pulmonary and respiratory system since 1977?

A. Yes.

Q. And have you continued seeing him and treating him up until the present time?

A. Most recently as August of this year.

Q. You just saw him two months ago?

A. Yes.

Q. When you first saw Robert in 1977 could you relate to us what history was obtained?

A. Basically Mr. Hill's complaints at the time that he came in the hospital were severe shortness of breath, chest pain and tightness. He had seen his family practitioner the day of admission and was admitted by the family practitioner to the Intensive and Coronary Care Unit with the family practitioner's concern being that he was suffering from a heart attack. He at that time had also given his family practitioner a history of exposure to paint in his place of employment. I was asked to consult on him because of persistent problems with shortness of breath, wheezing and sputum production. A heart attack had been ruled out. He had normal electrocardiogram and he had normal blood studies that indicated no

heart damage. Upon taking his history it indicated that the preceding October—he had been admitted at the end of June of 1977—but that in October of 1976 he began to develop symptoms of what he thought was a cold. Particularly he noted that it occurred about the time of

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the swine flu immunization. You will recall there was the massive swine flu immunization in 1976 and this was the time that he was able to remember—we never got swine flue shots before so it was the time he was able to focus on. He noticed that he had sprayed four cars at work, hoppers, with an epoxy-base paint and that he had difficulties in breathing after using the particular paint. He also noticed that initially that this would be worse on Mondays and Tuesdays when he would return to work and be reexposed to his painting materials, and not quite so bad on weekends. But he had the feeling that he had, a persistent cold for the eight months up until his admission to the hospital. The day of admission to the hospital he had been asked to inspect some cars apparently which had been recently sprayed with epoxy paint. He now had reexposure to the paint and felt a marked increase in his symptoms, again enough that his primary physician at that time thought he was having a heart attack. It was interesting to note when he was working with lead paint initially he did not notice these symptoms and very clearly was able to point out the association with the change in paint to epoxy and urethanes.

COMMENT: The witness has made it clear to the jury that the plaintiff's lung problems were attributable to using paint with urethane coating. He emphasizes the plaintiff's ability to associate his symptoms with the change from lead paint to paint with epoxy and urethane.

Q. This swine flu, this was merely to set a period of time?

A. Right.

Q. It had nothing to do with the swine flu?

A. Right, it was a date that he could remember. It's interesting, as I'm sure the jurors are aware, that major events take place in your life and you can date those very readily. The swine flu immunization program was a major event.

Defendant's Counsel: Object to his characterization of what went on in Mr. Hill's mind.

The Court: Sustained.

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(22) Definition of Cyanosis, Sputum and Toluene Organic Vapor

(By Plaintiff's Counsel)

Q. Doctor Bolton, assuming the hospital records indicated that he was cyanotic or had cyanosis, can you tell us what that is?

A. Cyanosis a bluish coloration to the skin that occurs when an individual is not having enough oxygen.

Q. And what causes that bluish in the nail bed and in his lips and toes when they're turning blue?

A. Oxygen is carried in the red cells by a substance called, hemoglobin. When enough hemoglobin is no longer carrying oxygen, then there will be a bluish change to the skin.

Q. What is sputum?

A. Sputum is the product that we spit out or expectorate as a result of secretions from the tracheal-bronchial tree.

Q. Are you also familiar with the organic chemicals known as toluene and xylene and ketones?

A. Yes.

Q. Have those been reported as also having respiratory symptoms?

Defendant's Counsel: I object. It's multiple characterization.

Plaintiff's Counsel: I'll rephrase it. (B1, Plaintiff's counsel)

Q. What has been reported with respect to the toluene organic vapor?

A. It's an irritant to the mucous membranes and those membranes line the eyes and nasal passages and sinuses and the tree. It also can cause a contact dermatitis.

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(23) Initial Treatment of Plaintiff During Hospitalization

Q. When Robert was first hospitalized did he go through— he was put into the Coronary Care Unit originally, wasn't he?

A. Yes.

Q. For people who have heart problems?

A. Yes.

Q. And he went through the various tests and was that excluded, he had no heart problem?
A. Yes.

Q. Then he was turned over into the respiratory care?

A. Yes.

Q. Doctor, what was your diagnosis?

A. I thought he had toluene—TDI asthma or sensitivity.

Q. During the course of his hospitalization did you place him under an aggressive bronchodilator respiratory program?

A. Yes, he required a very aggressive management program because of the degree of obstruction he was having because of the low levels of oxygen that it became necessary to put him on medication by vein, two specific drugs, one called Aninophyllin, which is a bronchodilator, and one called Solu-Cortef, which is a steroid drug, probably the most potent known. In addition, he was on a nebulization program with a machine to deposit medication directly in the breathing tubes. He also required oxygen while he was in the hospital to maintain his oxygen levels in a range that would be felt to be acceptable and not harmful to him. In addition, he was also taking other oral bronchodilators.

COMMENT: Both the attorney and physician have done their homework. The attorney has succeeded in getting the physician to give a concise

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breakdown of the plaintiff's history, the examinations performed, methods of diagnosis and treatment. A less careful presentation can leave loose ends that can later be exploited by the opposing attorney.

(24) Definition of Asthma and Respiratory Failure

Q. What is asthma?

A. Reversible obstruction to air flow into or out of the lungs.

Q. Can asthma—did Robert have an asthmatic or does he have an asthmatic condition?

A. Yes, he does.

Q. And what is the cause of his asthma?

A. I believe it has to be toluene, TDI.

Q. Is that your medical opinion?

A. Yes.

2. And can asthma, and has it been reported of asthma being induced or caused by TDI?

A. Yes, a number of times.

A. And that is your diagnosis with respect to Robert's condition?

A. Yes, it is.

Q. Is that correct, sir?

A. Yes.

COMMENT: The treating physician is permitted to give a medical opinion based on his examinations performed on the plaintiff and the plaintiff's medical records.

Q. What does respiratory failure mean?

A. Respiratory failure means the lungs are unable to adequately exchange oxygen and carbon dioxide. It's a critical state as far as the patient is concerned and the physician.

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Q. And assuming that he had a deterioration in his arterial blood gases, what does that mean?

A. That would mean his oxygen levels had dropped and that in his case his carbon dioxide levels had risen. If you recall, it's a two-part system, bring oxygen in and eliminate carbon dioxide. If the lungs are failing, they will not eliminate carbon dioxide and you'll get a buildup in the blood. In addition we can also measure the oxygen levels in the blood and in his case they were very low.

(25) Condition Indicative of Respiratory Failure

Q. And was that indicative of lung failure, respiratory failure?

A. Yes.

Q. Is that what you found with Robert?

A. Yes.

Q. Were any tests undertaken, any blood tests, to determine whether he had any allergies?

A. Well, specifically no test was done to determine whether he had allergy at that time. On the other hand, there are certain cells called eosinophils that are present in the blood in elevated amounts if there is an allergic component to an individual's disease, particularly at the time that they enter in an acute emergency state and before receiving any medicines. So if you had elevated eosinophils at that time, one could make an assumption that there would be allergy.

Q. Was his condition at that time consistent with no allergy?

A. Yes.

COMMENT: It is important to anticipate opposing counsel's arguments. Here, plaintiff's attorney prevented the opposing attorney from implying during cross examination that other causes for the condition were possible. The physician explained why he did not conduct tests to determine if an allergy existed; it was not suggested by the symptoms and the tests that had already been run.

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(26) Medication and Treatment of Plaintiff in Hospital

Q. And could you tell us what does the bronchodilation accomplish, what are you doing there?

A. Basically with bronchodilation we're trying to accomplish two things, first is to relieve the spasm of the smooth muscle surrounding the breathing tubes so they will open, and secondly to promote the removal of the secretions that are obstructing the breathing tubes.

Q. What approaches did you take with respect to medication and the approach to his respiratory and lung problem resulting from the TDI?

A. At that time he required medication by vein, by mouth and by inhalation.

Q. Was he also treated with corticosteroids?

A. Yes, we talked about the Solu-Cortef which is the most potent, was employed by the vein and, before he was discharged from the hospital, by mouth.

(27) Explanation of Chest Pains

Q. Assuming Robert has chest pains, that his chest feels tight and it's tightness like it's in a vice, what is causing that?

- A. I think there are three mechanisms that can be called upon to explain that. The first is that it's the work of breathing. The muscles and the bones of the chest can develop pain, tightness, discomfort. Secondly, with increased work of breathing, there can be what's called pulmonary hypertension or high blood pressure within the lungs. This is particularly true if the oxygen levels are dropping and that can produce chest pain or chest discomfort. And thirdly, if an individual was having inadequate oxygen or inadequate blood flow to the heart muscle, one can get pain from that.

(28) Relationship Between Pulmonary System and Heart

- Q. Doctor, what is the relationship between the pulmonary system and the heart?
- A. They are intimately related. The heart is pumping blood to the lungs and then the blood, which is now oxygenated, returns to the heart to be pumped out to the systemic circulation. You can have difficulties where the lungs create difficulties because of persistent spasm, secretion problems and get what we mentioned, the high blood pressure within the lungs called hypertension, which again puts a marked increased work load and strain upon the right side of the heart. The heart is a two-sided system. There is a left side which pumps the blood out to the systemic circulation, the muscles, the brain, the kidneys. And there is a right side which pumps the blood to the lungs- You can get failure of the right side of the heart called cor pulmonale which also will be associated with an enlarged liver, fluid retention, swelling of the legs and ankles.
- Q. When an individual such as Robert has the bronchial spasms and the lung breathing problems and has such attacks, does it affect and can it have an effect upon the heart?
- A. Yes.
- Q. Deleterious effect?
- A. Yes.

COMMENT: The danger of having heart problems has now been explained to the jury. This danger affects plaintiff's prognosis and also influences the jury's determination of damages.

(29) Effect of TDI on the Sinuses

- Q. Doctor, does the TDI also attack and involve the sinuses?
- A. Yes. The sinuses are also part of the respiratory tract and it can be irritating to the sinuses and increase the

amount of secretions that are being produced by the cells in the mucous membranes that line the sinus system.

Q. Did that occur with Robert?

A. Yes. He had X-ray involvement of the maxillary sinuses, which would be these right above the cheeks and the ethmoids which are in the back of the forehead. He was seen by an ear, nose and throat specialist who did a lavage of his maxillary sinuses and it was his opinion that there was no evidence of infection responsible for the sinusitis. And I think well have to say that also, that it was the result of stimulation of the mucous membranes of the sinus system by TDI.

Q. So that is significant?

A. Yes.

Q. There was no infection?

A. Yes.

Q. What is that significant of?

A. It would indicate that his pulmonary problem was not infectious either at that time.

Q. So, that if he was having the green and the discoloration, it resulted from the TDI?

A. Yes. The secretions that are produced, of course, that stay down there and are unable to be cleared, the DNA, which is within the nucleus of those cells, will deteriorate and give a green discoloration to the sputum.

(30) Definition of Dyspnea

Q. What is the term dyspnea?

A. Shortness of breath.

Q. And does Robert's involvement, does his injury involve both lungs?

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A. Yes.

Q. And the entire respiratory system?

A. Yes.

(31) Patients History Following Discharge from Hospital

- Q. Now following the discharge from the hospital did Robert remain under your care during 1977?
- A. Yes.
- Q. And did you see him at periodic intervals during that year?
- A. Yes.
- Q. Did you place him on a program of outpatient bronchodilation and respiratory therapy for him to do at home?
- A. Yes. Mr. Hill was on a continuous program of bronchodilative therapy, taking medication by mouth and by inhalation.
- Q. During the course of your various examinations has he continued to demonstrate forced expiratory rhonchi and wheezes?
- A. Yes, he has.
- Q. Of what significance are those?
- A. It indicates continuing obstruction to the bronchial tree.
- Q. Did you continue seeing Robert at periodic intervals during 1978, 1979 with respect to making certain that he was following a proper respiratory—

Defendant's Counsel: Object, leading.

The Court: Sustained as to the form.

COMMENT: The defense attorney finally objects to the plain tiff's attorney's leading his witness. The defense has, in effect, allowed the plaintiff's attorney, rather than the witness, to relate the medical treatment the plaintiff received after discharge from the hospital.

(By Plaintiff's Counsel)

- Q. What was the purpose and what were you doing with respect to Robert in 1977 and 1978?
- A. The goals of treating any patient is to, first of all, try to maintain him in as a disease-free state as possible yet we have to recognize that that is not always obtainable. It becomes necessary to see the patient from time to time to see if any alteration should be made in

his program. On occasion a patient can stop his medicine. In addition, it is important to sit down and review with the patient his approach to his disease and those things which may allow him to stay out of the doctor's office, out of the hospital, decrease the cost to the patient.

Q. And with respect to the expiratory bronchi, these wheezes and rhonchi, which parts of the breathing tubes, large versus small, would this show involvement of?

A. The large.

Q. And during 1978, 1979 and 1980, did you continue seeing Robert at periodic intervals?

A. Yes.

(32) Sensitization of Plaintiff's Respiratory System

Q. Doctor, what effect has the TDI had with respect to sensitization of his respiratory tract, the pulmonary system?

A. There are two mechanisms that have been invoked that are called upon as to the reason why individuals get into difficulties with TDI. The first is an allergic mechanism which the body develops a specific antibody to TDJ so that when you come in contact with it at much, much lower doses than would affect normal individuals, persons will develop a recurrence of his symptoms. I don't really think that's the mechanism in Robert, Mr. Hill. The second mechanism though is a sensitization mechanism which is independent of the development of

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any antibodies or allergy state. And in this, if you remember, we mentioned that there are the cells that line the breathing tubes that increase mucous production in the mucous glands and there are muscles that surround the breathing tubes. When these are stimulated or sensitized initially by TDI they may then develop a state that any kind of a stimulus, any kind of a physical stimulus, no longer TDI, can reproduce the initial symptoms of cough, wheezing and shortness of breath. This can include cold air, getting a cold, hair spray, perfumes, deodorant, newspaper print, exercise, strong wind, viral infections. And I believe that's what has happened with Mr. Hill.

Q. Ta that what you've observed with respect to Robert Hill?

A. Yes.

Q. And as a result have you cautioned him with respect to his exposure to people that are sick of such an environment?

A. Yes, particularly during winter months when there is a high incidence of viral infections

and flu-like illnesses, probably the worst place to be is in a doctor's office because everybody there is sick and it's very easy in confined quarters to get a viral infection. To Mr. Hill this would be a devastating complication. In addition during the cold air, cold weather months, again, these are physical stimuli that can exacerbate or make his condition worse and he's been advised to avoid those situations. Again, a certain amount of common sense comes into play. When one recognizes that odors, perfumes, hair sprays, whatever, also cause difficulties, he's advised to avoid using that kind of material. And, unfortunately, these individuals may be very sensitive so that they can get out into public, a very nice warm day without any problems and walk by a lady who has a very nice smelling perfume, but again that odor will produce bronchial spasm.

The Court: We'll take our morning recess at this time.

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(Brief recess was taken.)

The Court: You may proceed.

(By Plaintiff's Counsel)

- Q. Doctor, could you explain for us what actually causes the secretions, what are they caused by, what purpose are they and what is involved in that mechanism? Perhaps you might want to utilize the board.
- A. I'll draw a bronchial tube in cross section as if you were looking down the tube like a straw. Now those muscles that we talked about would be surrounding it. But within the lining of the breathing tube are various types of cells. They totally surround it. There are also other cells that have a carpet-like fringe on them. The major cells are called pseudo-stratified ciliated epithelial cells, which is really a mouthful, but basically that means a long cell with fringe on it like the fringe on a carpet. This fringe beats rhythmically to propel secretions up to the larynx or the voice box so we can cough it out. The other cells that can be found along here are called goblet cells or mucous cells. In addition there are also bronchial glands within the wall of the bronchial tube. Stimulation of the goblet cells, mucous cells or the bronchial glands will then lead to an increase in the amount of secretions within the breathing tube. This can lead, of course, to cough, sputum production and shortness of breath particularly if taken in conjunction with spasm of the muscles that surround the breathing tube. Now normally we produce about a teaspoon of sputum a day. That just sort of acts as a lubricant as far as the breathing tubes are concerned. And again, it is propelled by these cells that have the fringe on them so we can expectorate if we need to. But in pathological conditions, that is disease states, there is increased production of secretions in response to whatever kind of stimulus it may be. In Mr. Hill's case we have a history of TDI exposure. We know that that can cause sensitization to the nerves that control the mechanism to produce secretions so that later on any kind of a physical stimulus, dirt, dust, odors, the things that we

have already alluded to, will cause an increase outpouring of secretions, spasm, sputum, shortness of breath.

(33) Permanency of Lung Damage

Q. And how has the TDI damaged the bronchial system in such a man to cause this increase in secretion?

A. The mechanism is basically that of sensitization so that this area is now—or the entire breathing tube is now sensitive to any kind of stimulus to it to do this. The exact cellular mechanism is postulated to be on what's called a pharmacological basis or inhibiting those things which are necessary to produce opening of the breathing tubes and to decrease the amount of secretion.

Q. With respect to Robert, is that permanent damage?

A. Yes.

COMMENT: It is vital to establish the permanency of plaintiff's condition. It cannot be left for the juror's to wonder if with time, and avoidance of those matters that caused the medical problems, plaintiff would recover or his symptoms would lessen.

(34) Description of Pulmonary Function Tests

Q. Now, Doctor, could you also tell us what it is about the pulmonary function tests and how a pulmonary function test can determine the small airway obstruction?

A. Pulmonary function studies are a way of evaluating whether the individual has normal lung function or whether he has abnormal lung function. We deal with abnormal lung function, we're basically concerned with two types or a combination of those two. The first would be restrictive lung disease which would be best defined as the inability of the lungs to expand to its fullest capacity. An obvious way of thinking of that would be if I took a lung out. Now I would only have half the capacity so I would be restricted, or if I broke all my ribs and it hurt and I couldn't take a deep breath, my lungs could not expand. The second thing we're concerned about, particularly in Mr. Hill's case, is obstruction to

tion to air flow out of the lungs. Basically the problem is not so much of one getting the air in, it's getting the air out. So we do pulmonary function studies that divide into two types. The first is called spirometry and the second is called lung volumes. And if T may draw a few curves here. When we're sitting at rest we have what's called tidal breathing,

this pattern here. We're moving in about six hundred cc's of breath. It depends on our height and age, but basically about six hundred cc's with a breath, and of course, we're not giving it any thought. The total volume of air that's within the lung would be called the total lung capacity or the PLC. Now if we have an individual breathe normally and take in as deep breaths as they can and blow it out as hard as they can, we would now measure what is called a vital capacity. As you can see, there is still a difference though between the total capacity, or the capacity of the lungs, and the vital capacity. The difference is called the residual volume or the RV. This is the amount of air that remains or resides in the lungs at the end of a maximal expiration. Now we can measure flow rates, that is obstruction, by looking at this curve. We can measure the amount of air that remains in the lungs by doing special testing called lung volume which will measure the residual volume and the total lung capacity. In addition, one of the -tests is called the functional residual capacity and that is the volume of air that remains in -the lung after a normal breath. So we have residual volume, the amount of air that remains in the lungs after a maximal expiration; the functional residual capacity, the amount of air that remains in the lung at the end of a normal breath; a total lung capacity which is the maximum amount of air that the lungs can hold; and the vital capacity which is the maximum amount of air that we can exhale with one breath.

Now understanding these a little bit, let me move to the fact that if we have something that is obstructing air flow out of the lungs because the air is not able to get out of the lung, we will see an increase in the residual volume and we will see an increase in the functional residual capacity. Why is that, the lung capacity

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remains the same, but we're not able to get all the air out. So what we are measuring then is the amount of air that remains in the lungs, either at the end of a normal breath, functional residual capacity, or at the end of a maximal breath which is the residual volume. So increased residual volume and functional residual Capacity will be seen in individuals who have obstruction to air flow out of the lungs.

Q. And is that what you've observed with Robert?

A. Yes.

Q. And assuming that just the week before last the residual volume was 2.21 out of a predicted 1.76, and the FRC was 3.69 out of a predicted 2.49, would those be consistent with the type of damage that you've described?

A. Yes.

Q. You may proceed, Doctor.

A. The second test again this is called the measurement of lung volume. We're looking at various volumes within the lungs. The second test, though, is a test that combines the

vital capacity and a measurement of the amount of air that has moved out of the lung with time, which would mean a flow rate, the movement of air so much per second. And what we do there, we're going to tip this curve upside down, we have an individual breathe normally. Then he takes in as deep a breath as he can and he blows it out as hard and fast as he can. Now if you remember that's just the vital capacity because we're looking at it in a different way. Along this axis we then have volume, that is the amount of air that is being breathed out. And along this axis we have time and this is called a time-vital capacity. Now if a person has the restrictive disease that we talked about earlier, he may get all his air out normally. If an individual has obstruction to air flow, he has a curve that will look like that, which will mean that with time starting at zero seconds, half second, one second, three seconds, there is obviously a decrease in the amount of volume of air that

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gets out at one point in time. For instance, if we say this is one liter, it wouldn't be, but we'll take that for purposes of discussion, this individual here would get one liter out in a half a second but it might take him one and a half seconds to get out that same volume of air. This is obstruction to air flow. This is generally measured by then what is called the FEV1, forced expiratory volume at one second. And people who have obstructive disease in the large breathing tubes will frequently have a decreased forced expiratory volume in one second, particularly when it is put in relation to the individual's forced vital capacity. The second thing we can do to look at the small airways that we had talked about earlier is to look at that part of the curve, we can divide the curve into quarters so we have one quarter, two, three quarters and one hundred. The PEP 25/75 that measures small airway obstruction is the volume of air that comes out between the twenty-fifth percentile and the seventy-fifth percentile on this curve. Decreasing the measurement along this part of the curve, this expiratory curve, correlates with small airways obstruction. These are the individuals that also have that frequency of dependency compliance, increased pressure in order to move in the same volume of air. It gets worse as your respiratory rate increases. So then we have the forced vital capacity and then we have the forced expiratory volume in one second, and then the FEV 25/75. The latter two are measurements of the obstruction to air flow. In addition if we can go back to the first diagram for obstruction to air flow, then you will expect a decreased FEV1, a decrease in FEV 25/75 and an increased residual volume in functional residual capacity.

(35) Results of Tests Performed on Plaintiff

Q. Now, Doctor, is that the type of damage that you've observed in Mr. Hill.

A. Yes.

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Q. And have your pulmonary function tests revealed that kind of damages

A. They consistently appear that way.

COMMENT: Counsel very effectively gets the witness to first explain the pulmonary function tests and their significance in detailed terms. It is only after the witness finishes the explanation that he relates these tests to the plaintiff's situation.

Q. Doctor, let's assume that just the week before last in the pulmonary functions done at St. Mary's that Robert had an actual FEF 25/75 of 1.01 of a predicted 2.871

A. That's very severe, 1.01.

Q. Yes, sir, very severe what?

A. Obstruction to the small airways.

Q. And if it's showing 35 percent of predicted?

A. Again it would just substantiate the severity of this.

Q. Let's assume that his PEF was 2.73 of a predicted 7.83. What would that indicate?

A. The peak expiratory flow rate is that point on this curve at which you are moving the most amount of air. If that value is diminished, again obstruction to air flow. His value was 2.73 liters against a predicted 7.83 or a percentage of thirty-five percent. Again, thirty-five percent is severe obstruction to air flow confirmed by the FEV 25/75 and the peak expiratory flow rate.

(36) Bronchodilator of Minor Benefit to Plaintiff

Q. Let's assume he's given a bronchodilator. What will that do?

A. Bronchodilators are the medicines that we talked about that can be given orally, by vein or by inhalation. In doing a pulmonary function test you usually do three or four tests before the bronchodilator is given, and then one after. And you have the individual inhale medication. At our hospital we use a drug called Bronchus

Isoetharine. Some hospitals will use Isoproterenol. You wait ten to fifteen minutes after the individual has inhaled two or three squirts of this and then repeat this test. Now individuals who have obstruction in the large airway may actually show some significant improvement because the bronchodilators have the greatest benefit on the larger breathing tubes. However, they may not show much improvement in the smaller breathing tubes. So following inhaled bronchodilators it would not be surprising to find an

improvement in the FEV1 because that's measuring large airway, but not much improvement in the forced expiratory flow 25/75. And of course the medications that we're talking about are medicines that Mr. Hill is taking on a regular basis to try to promote bronchodilation and improvement in his breathing tests.

Q. So you expect an improvement. Let's assume that the post medication test went on the FEF 25/75 to L77 or a percentage change of seventy-six.

A. That's just a percent change against his initial but he still is underneath the normal.

Q. Percent of predicted, sixty-two.

A. He's still sixty-two percent, he still has a significant obstruction to the smaller breathing tubes on his FEF 25/75.

Q. On the PEP he went to 5.51 or seventy percent.

A. This is more a measurement of large airways so again I'm not surprised we would have improvement, but he is still below normal.

(37) Effect of Cold Air on Plaintiff a Condition

Q. Thank you, Doctor. Doctor, what is it about Robert's injury that is affected by cold air?

A. It's the same thing that we've talked about, a physical stimulus; cold air is a physical stimulus. The purpose of the nose is to humidify and to warm inspired air. But if

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you get out in cold, air and you're not able to always warm the air outside, that's a protective device for the lungs, the cold air gets into the lungs, creates the irritation, the spasm and the secretion. Chalk dust would do the same thing to him.

COMMENT: Counsel succeeds in getting the witness to cover all bases. No matter what subject the witness is testifying about (sensitizations of respiratory system, the pulmonary function tests, continuing bronchodilative therapy program, types of medication, etc.), it all intimately points to one conclusion—the plaintiff has been permanently injured as a result of exposure to toluene diisocyanate (PD I) and he will always be under a doctor's care. Opposing counsel has a very formidable task, in trying to show otherwise.

(38) Effect of Plaintiff's Medications

Q. Now, Doctor, with respect to this machine that he's using, this mist and inhaling the Bronshosol, what is actually happening when he is inhaling the mist from the machine into his lungs?

A. The medication, Bronchosol, is a bronchodilator. It works by relieving the spasm of the muscles around the breathing tubes to promote dilation and at the same time to promote the coughing of the secretions so we can unblock the breathing tubes as far as secretion and sputum is concerned.

Q. What about the Vanceril spray?

A. Vance HI is an inhaled steroid. If you recall, we mentioned that steroids are the most potent bronchodilators. It is basically used as a preventive. It does not treat acute attacks. By using the spray we can avoid frequently using oral steroids which can have a tremendous amount of side effects as far as the individual is concerned.

Q. And what about the two medications that he's taking by pill, the Alupent and the Theolair?

A. Theolair falls into a group of drugs that are dilators of the breathing tubes. Specifically they act on sites within the cell to cause relaxation of the muscles. The Alupent

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is a classic drug called a sympathomimetic. It mimics the action of our bodies on the sympathetic system. The sympathetic system of the body produces adrenalin or epinephrine. That is a drug that is related to Epinephrine and again produces bronchodilation by relaxing the smooth muscles and decreasing the production of secretions.

Q. What is the Theophylline test?

A. One can do a blood test for theophylline. It's very simple. In our hospital we can get them as an emergency test and have them back in thirty minutes.

Q. What is the test?

A. It tests the blood level of theophylline.

Q. That would be the Theolair?

A. Yes.

Q. So that would be one of the four medication types that Robert is taking?

A. Yes.

Q. What dosage or what type of theophylline do you have Robert under?

- A. Robert is on a trade name drug called Theolair. Theolair has a relatively short duration of action, about six hours. So consequently if an individual goes twelve hours without taking this dosage, he may have a very low level in his blood if a blood test were to be obtained. There are other preparations on the market but at the time Robert was in the hospital they were not available and it's usually easier to keep a person on one program rather than try to start making changes in a program.

(39) Symptoms If Plaintiff Did Not Take Medication

- Q. So let's assume then Robert has not taken his medication but say he was going to have a test taken and he took it the night before at nine o'clock before he went to

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sleep, what effect would it have on him personally the next morning if he doesn't take his medication?

- A. He would be more short of breath by not taking his medication.

- Q. Make him feel worse?

- A. Tighter, more spasm, more secretion. And, of course, if a blood test -were obtained at that time it may show negligible levels of theophylline.

- Q. So if Robert had not taken his Theolair that morning because of the tests and the theophylline showed a .80, would that be inconsistent?

- A. No, that would be quite consistent with not taking his medicine for twelve hours.

(40) Continuation of Illness to Present Time

- Q. Now, Doctor, by the way, have the injuries and have the damages that you've observed in Robert, have they continued on to the current time?

- A. Yes.

(41) Medical Opinion that Respiratory Problems Attributable to TDI

- Q. Assume that prior to October or the fall of 1976 Robert was in generally good health, that he had no respiratory problems, no physical problems that he was aware of, felt good, no shortness of breath, no coughing and no difficulty of the respiratory symptomology, that in 1976 and 1977 he was painting, required to paint with paint containing TDI in high concentrations, I'd like you to further assume that he first began developing what he characterized as a cold and respiratory type of symptoms, coughing, and that it continued to progress and get worse over a period of six or eight months, and I'd like you to further assume that he was then hospitalized in June of 1977, I'd like you to assume that he came

under your care and your examination and findings

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that you've described and the injuries that you've described since that time, do you have an opinion based upon a reasonable medical certainty as to whether the injuries and damages with respect to Robert's respiratory and pulmonary system that you've described were directly related to his exposure to TDI?

A. I think given all those assumptions and given Mr. Hill's history and his clinical course and what we know he had been exposed to, the conclusion has to be that this is due to the TDI.

Q. And is that your opinion?

A. That is my opinion.

Q. Is there any doubt about it in your mind?

A. There is no doubt about it in my mind now nor was there when I first saw him in 1977.

Q. And is that based upon five and a half years you've had to work with and learn and treat this patient?

A. Yes.

Q. And also based upon your experience and training?

A. And training, yes.

Q. And based upon your knowledge and study of TDI and its effects?

A. Yes.

COMMENT: Just in case the jurors are not yet certain that TN exposure has caused the plaintiff's illness, counsel gets the physician to summarize for the jurors that his opinion has never been in doubt and is based on his overall experience with studying and treating cases involving TDI and his actual treatment of the plaintiff.

(42) Prognosis

Q. Doctor, what is his prognosis now, what is the future?

A. Well, Mr. Hill has had limitation of activity over the last five years. I would expect and anticipation that he

would continue to have difficulties. His activity levels have been restricted in part because of what I've told him to do and in part because of what he has found he cannot do. Each exacerbation or worsening of his disease has the potential of actually killing him, although hopefully that won't happen because of the medication program and telephone communication between him and me if he has difficulties. Certainly it's been recognized that the effects of the lungs, long term, can also have effects upon the heart and he could undergo some cardiac deterioration with age as well.

(43) Opinion as to Permanent Lung Damage

Q. In your opinion is his condition permanent?

A. Yes.

Q. In your opinion will he ever get off the medication that you have him on and the bronchodilator therapy program that you have him on?

A. No.

Q. What effect has it had upon his activities such as walking and physical activity?

A. From my own observations he gets severely limited with walking just short distances. Of course, this leads to frustration. Any patient who has a chronic illness particularly if they were in good health before the onset of their illness has difficulties in coping and often will develop anger, hostility about the situation, their apparent inability to do the things that they always wanted to do or were able to do.

Q. Could he, in your opinion, get worse?

A. Yes.

Q. In your opinion, based upon your examination and treatment and the injuries and damage that he has, will this have an effect upon his life expectancy, his longevity?

A. It could very well have an effect upon his life expectancy and his longevity.

Q. In your opinion and based upon your knowledge and experience can anything be done to improve his condition?

A. There are no medications available at this time that I could think of that would help him. He cannot avoid such things as weather change and he has to lead his own life as best he can and he will be limited because of that.

Q. And is his condition one that is permanent and on going for the rest of his life?

A. Yes.

Plaintiff's Counsel: I have no further questions.

COMMENT: In addition to medical bills, the extent of disability, and prognosis, the plaintiff's ultimate award includes his pain and suffering. The jurors can see the plaintiff's continuing pain as he sits in the courtroom. In addition, the expert has made it clear that the plaintiff has suffered and will continue to suffer, due to his inability to lead a normal life and the accompanying apprehension about his future health and life expectancy.