From the Reading Room to the Courtroom—The Use of Molecular Radionuclide Imaging in Criminal Trials

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INTRODUCTION

Recent years have witnessed an expanded use of PET or single-photon emission CT (SPECT) for a wide range of clinical applications, including staging and restaging examinations in oncology, assessment of cardiovascular diseases, and imaging of brain abnormalities [1-4]. Given the ability of PET and SPECT to demonstrate molecular-level abnormalities in brain function, these imaging techniques have also recently been introduced in criminal trials to assess regional brain tissue function. The introduction of molecular neuroimaging into the courtroom has raised concerns about a potential "Christmas Tree Effect" (ie, that the colorful images produced by a PET or SPECT scan may unjustifiably bias jurors) [5]. Instead of weighing all of the evidence regarding a defendant's culpability, jurors may consider a PET or SPECT neuroimaging study as definitive proof of diminished capacity or incompetence [5].

In a mock study that included a staged murder trial, Gurley and Marcus asked 396 participants to render a verdict of either guilty or not guilty by reason of insanity (NGRI) [6]. The "jury" rendered a verdict of NGRI more often if the defense showed a brain lesion or evidence of prior brain trauma using MRI, with odds increasing by

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1.34 for brain lesions and by 1.61 for brain trauma. In addition, the authors also reported on an additive effect of neuroimaging plus brain injury testimony (which was a statement that the defendant's disorder began after suffering significant brain injury in a car accident). As this scenario suggests, the presence of neuroimaging can increase the likelihood of finding a defendant NGRI [6]. In a similar vein, McCabe and Castel showed that MRI scans are much more influential than a bar chart that displays actual data counts, mainly due to the fact that a scan offers a physical basis for abstract cognitive processes (ie, "appealing to people's affinity for reductionistic explanations of cognitive phenomena") [7]. Thus, the potential for undue influence of juries also extends to "plain" black-and-white images, such as CT or MRI.

Although studies showing such bias for molecular neuroimaging have yet to be carried out, the trend toward increased utilization of PET and SPECT studies by a defendant's attorney, in particular in the sentencing phase of a trial, may raise reasonable doubts as to the legitimacy of such imaging modalities in a criminal trial setting [5]. Such concerns have been expressed by Jones et al: "We are concerned that brain imaging can be misused by lawyers (intentionally or unintentionally) and misunderstood by judges and jurors" [8,9]. This concern has been even more sharply defined by Blume and Paavola: "Neuroimaging can help make a difference between life and death" [10].

In the present article, we aim to provide a brief overview of the utilization of molecular brain imaging during different criminal trial phases and present several landmark trials in which PET and SPECT have been used as mitigating evidence by the defense team.

ADMISSION OF MOLECULAR BRAIN IMAGING AS EVIDENCE DURING DIFFERENT CRIMINAL TRIAL PHASES

As summarized by Rushing, there are four different phases of potential admissibility of PET or SPECT scans during a criminal trial [5], as follows [5,11].

1. Competency or Fitness to Stand Trial

As a prerequisite and a core principal of the American criminal justice system, the concept of competency or fitness to stand trial (CFTS) dates back to Judeo-Christian thinking [12]. CFTS assures that an accused facing a criminal trial is competent to understand and meaningfully respond to the charges placed against him or her. As such, CFTS can be raised at any preverdict stage of a trial [12]. In terms of molecular imaging, a PET or SPECT scan may be useful to provide evidence regarding the CFTS of the defendant and to reflect on an accused's capability to stand trial [5].

2. Guilt Phase

The prosecution must prove that the defendant committed the crime (*actus reus*) and had criminal intent (*mens rea*). *Mens rea* is the specific state of mind required by law to convict a defendant of a crime. The Model Penal Code establishes four categories of *mientes rea* according to degree of blameworthiness*:* (1) acting purposely, (2) acting knowingly, (3) acting recklessly, and (4) acting negligently. Although *mens rea* is established during the guilt phase, it has significant implications for the penalty phase—with more severe penalties generally corresponding to greater degrees of blameworthiness [13]. Thus, the guilt phase is to determine whether the defendant has the requisite *mens rea* for a particular crime [10]. In brief, molecular imaging may assist in evaluating altered metabolism to brain regions, in particular those that are critically involved in judgment and impulse control. Abnormal PET or SPECT scans can be presented by the defense attorney to undermine the prosecution's argument that the defendant possessed the required state of mind to commit a crime [5].

3. Sentencing or Penalty Phase

As outlined by Blume and Paavola, the penalty phase of a capital murder trial should not be considered as a determination of facts ("Did the accused do it?"), but a moral choice ("Does the accused deserve to be punished with the death sentence?") [10]. Therefore, mitigation plays a pivotal role during the penalty phase of a trial. As described by Stetler, the National Mitigation Coordinator for the federal death penalty projects: "Mitigation is not a defense to prosecution. It is not an excuse for the crime. It is not a reason the client should 'get away with it.' Instead, mitigation is a means of introducing evidence of a disability or condition which inspires compassion, but which offers neither justification nor excuse for the capital crime. Unlike the insanity and competency requirements, mitigation need not involve a mental 'disease' or 'defect'" [10,14].

Evidence for such a "mental disease or defect" may also be provided by molecular imaging, such as by demonstrating alterations to areas of the brain that are involved in cognitive functions such as judgment and

impulse control [5]. Therefore, PET or SPECT may serve as a means to provide mitigating evidence during the sentencing phase in favor of the accused. So long as the jury understands that there is mental incapacity (illness or retardation) of any sort, it may lead to a less harsh sentence [5,11]. Notably, molecular imaging scans of the brain are regularly admitted during the penalty phase of a capital trial, because the defendant and the referring team have a constitutional right to come forward with any sort of evidence that may mitigate against the death penalty [5].

4. "Too Little, Too Late"—Ineffective Assistance of Counsel Claims

The accused may also claim that his or her attorney failed to provide adequate and sufficient legal assistance [15]. This concept can be further subdivided into (a) potential conflict of interest of the lawyer or (b) a conflict-free ineffective assistance of counsel (ie, a "professionally unreasonable error" committed by the defense attorney) [16]. These claims are common, and the American Bar Association assumes that almost every defense lawyer may face an ineffective assistance of counsel claim [17]. Failure to present evidence of brain abnormalities (eg, by the use of molecular imaging modalities such as PET or SPECT) may be a reasonable basis for a claim of ineffective assistance of counsel, particularly given its significant impact on sentencing. Notably, this can even lead to overturning death penalties [5,11].

APPLICATION OF SPECT IN LANDMARK CIVIL TRIALS

SPECT is often used in toxic tort cases (ie, a legal claim for harm caused by exposure to a dangerous substance or chemical) [18]. For instance, in *Rhilinger v Jancsics et al,* [19] the plaintiff sued her landlord for storing chemicals in the apartment building's basement. Those chemicals, which had been diffused into the plaintiff's apartment, may have provoked "toxic solvent encephalopathy" and "multiple chemical sensitivities." The judge concluded that the plaintiff's expert noted that SPECT can be useful to further investigate this claim, but not to *establish* the diagnosis of toxic solvent encephalopathy. Thus, although it was admitted into evidence, SPECT could not contribute to the two major issues that needed to be proven for a toxic exposure plaintiff. Those issues are (1) that the toxic exposure is actually capable of provoking the alleged brain injuries and (2) that the level and duration of the exposure can cause those injuries [20,21].

The case of *Rhilinger v. Jancsics* is in contradistinction to *Summers v Missouri Pacific Railroad System* [22]. In that trial, the court did not admit SPECT into evidence. In June 1993, while traveling from Oklahoma to Texas in a locomotive, the plaintiffs realized diesel exhaust was in the cabin. After experiencing headache, dizziness, nausea, and difficulty breathing, plaintiffs were treated in the Environmental Health Center in Dallas, where the diagnosis of toxic exposure, caused by "chemical sensitivity," was established. The referring physician concluded that the condition, caused by the diesel exhaust, rendered plaintiffs permanently disabled with respect to railroading and most other types of employment. However, the district court decided that SPECT "have been the subject of much criticism by the scientific community as not having met acceptable scientific levels of methodology and criteria, and are not designed to test for the recognized medical condition of chemical sensitivity" [21-23].

Apart from toxic tort cases, SPECT has also been used to demonstrate or rule out brain injuries in car accidents. For example, in *Fini v General Motors Corp,* a Corvette available for employee use was being driven by a defendant working for General Motors Corporation who collided with the plaintiff's vehicle [24]. SPECT was used to demonstrate frontal brain damage in the plaintiff. In this automobile negligence case, the jury awarded the plaintiff $4.26 million after trial [21,24,25].

APPLICATION OF PET IN LANDMARK CRIMINAL TRIALS

Analogous to shifts from SPECT to PET in the clinical setting, recent years have also witnessed the expanded use of PET in the courtroom. Notably, 2-deoxy-2-[^{18}F]-fluoro-D-glucose PET (FDG-PET) scans for assessing brain metabolism have increasingly been admitted in death penalty litigation to provide evidence supporting an insanity defense or diminished capacity, as illustrated in the following cases [5].

In *People v Weinstein,* [26] a FDG-PET scan was introduced by the defense team. The defendant was accused of strangling his wife and throwing her from a 12th-story Manhattan apartment to cover up the murder as a suicide. The FDG-PET/CT images demonstrated an arachnoid cyst in the frontal lobe, and this finding was used to support an insanity defense. Not surprisingly, the prosecution attempted to

exclude the scan from evidence. When the judge admitted it to trial, the prosecution agreed on a plea bargain (reduced charge of manslaughter), fearing that the PET-based Christmas Tree Effect would significantly bias the jurors [5,26-28].

More recently, PET and MRI helped to overturn two separate death sentences for the same accused individual. First, in *Commonwealth v Pirela,* Mr S. Pirela received his first death sentence for murder [29]. In 1981, Mr M. Pirela (the brother of the accused S. Pirela) was visited at his home by the victim and a companion to "shoot" heroin. Albeit having used heroin from the same source, only M. Pirela became ill, was delivered to his home by the victim and his companion, and was found dead by his wife the next morning. The cause of death was determined to be a drug overdose. However, S. Pirela accused the victim of being responsible for the death of his brother, and the victim was beaten, injected with battery acid, and strangled to death with a pair of socks [29]. In addition to this trial, the defendant received his second death sentence in a separate murder trial (*Commonwealth v Morales*) [30,31]. The defense team provided brain MRI and PET scans during the trials, which demonstrated mitigating factors of brain injury suggesting reduced mental capability of the defendant. The jury was persuaded by this mitigating evidence, and the death sentence was overturned to life in prison for both cases [26].

Another prominent murder trial was that of *McNarama v Borg* [32]: B. W. McNamara was accused of killing four of his relatives, and PET was introduced to support the hypothesis that the accused suffered from schizophrenia, which in turn may have lead to reduced impulse self-control. Molecular imaging was used to provide evidence of a hypoactive prefrontal cortex of the defendant [33]. The jury recommended a sentence of life in prison, admitting that the brain images persuaded them in the decision not to sentence the accused to death [26,27]. Altogether, these high-profile cases demonstrate how neuroimaging and, in particular PET, can significantly impact the outcome of a criminal trial [5,26].

However, a PET scan may not always be helpful to prove mitigating circumstances. In *State v Stanko* [34] Mr Stanko visited his friend (the victim) at his residence to conduct an armed robbery and fatally shot him in the chest. During the trial, a PET scan was conducted to show that Stanko was not capable to understand "legal right from wrong." Regarding an actual injury to the frontal lobe, the expert witness stated that this "injury would significantly compromise and impair an individual's ability to exercise judgement." Nonetheless, the jury recommended that the accused should be sentenced to death [34,35].

Apart from using molecular neuroimaging to explain legally relevant behavior, PET has also been used in trials as proof of actual trauma. In *Blodgett-McDeavitt v University of Nebraska* [36], the plaintiff used PET to prove her claim of electric shock brain injury. In another civil case (*Hose v Chicago Northwestern Transp Co*) [37], the plaintiff used PET to support the diagnosis of manganese encephalopathy after having been exposed to dust and fumes containing manganese [35].

APPLICATION OF COMBINED MOLECULAR IMAGING AND FUNCTIONAL MRI IN LANDMARK CRIMINAL TRIALS

This review mainly deals with molecular imaging; however, functional MRI has been referred to as one of the most remarkable technologies for lie detection, mainly due to its increased availability, cost-effectiveness, and acceptable balance between spatial and temporal resolution [38]. Notably, MRI has already been used in combination with PET in multiple capital murder cases: For instance, in *United States v Montgomery* [39], the defendant Mrs Montgomery was accused of kidnapping resulting in death. The victim was in regular contact with the accused through an online message board dedicated to dog breeding and reported to the defendant that she was pregnant. Although having been sterilized a decade before, the accused also claimed that she was currently pregnant. At month 8 of the pregnancy of the victim, Montgomery arranged a meeting, killed the expectant mother, opened the abdomen with a kitchen knife, removed the fetus, and told her husband that she had just recently given birth to a child. Both PET and MRI were used during the trial to prove that the brain of the accused had abnormalities consistent with pseudocyesis. The defense expert stated that the brain MRI showed reduced brain volumes in the right hemisphere, and the PET scan demonstrated increased activity of the limbic and somatomotor regions. However, a government expert stated that these imaging modalities are not commonly used to determine pseudocyesis and thus the evidence was excluded by the court, mainly because of minimal probative value. The accused was sentenced to death [40].

FUTURE PERSPECTIVES AND THE ROLE OF RADIOLOGY FOR THE USE OF MOLECULAR IMAGING IN CRIMINAL TRIALS

Neuroimaging PET and SPECT as an evolving field

Beyond the current clinically available radiotracers such as [^{18}F]-FDG, new agents that target the nicotinic acetylcholine receptor or specific proteins involved in neuroinflammation may have a role in the objective identification of patients with underlying psychiatric disorders [41-43]. Other novel radiotracers coming to the forefront in molecular neuroimaging evaluate the dopamine and reward system [44]. Thus, adding to the complexity of using PET in a criminal trial setting, future investigations should also consider those novel radionuclides to assess the dopamine system, which is critically involved in motivated approach behavior [45].

Role of Radiology

With the introduction of PET and SPECT in the courtroom, reasonable doubts have been raised about a potential Christmas Tree Effect from those colorful scans, which may have a significant impact on a jury's deliberative process [5]. Thus, the field of radiology will need to take steps to ensure the expert witnesses provide meaningful testimony and generate prospective data that corroborate that findings on imaging portend the actions or attitudes of defendants. Moreover, if there continues to be an expanded use of (molecular) brain imaging in criminal trials, radiology has to play an essential role in educating the public on both the promise and the pitfalls of this trend.

TAKE-HOME POINTS

- Recent years have witnessed the expanded use of (molecular) brain imaging in criminal trials.
- SPECT has been preferably requested in toxic tort cases, and PET has been used to provide mitigating evidence of brain structure abnormalities.
- If there continues to be a trend toward use of imaging in criminal trials, the field of radiology will need to take steps to ensure expert witnesses provide meaningful testimony and to educate the public on both the promise and the pitfalls of this trend.

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