The Cover: Prescription medication misuse and abuse contributes to the drug problems in this country. See article p. 1.
During an early morning armed robbery of a convenience store, the sole clerk is shot. A suspect is arrested 20 minutes later, several blocks away without a weapon. On his hands, however, is gunshot primer residue (GSR), an invisible clue that could be used by investigators in this and most other crimes involving a firearm. Unfortunately, in many such instances, this valuable evidence would not be made available to investigators or jurors. Why not? There are various reasons, including an unfamiliarity with proper procedures for collecting GSR for analysis. This article addresses the strengths and weaknesses of these processes and offers suggestions for more effective use of this often overlooked evidence.

Background

The explosion inside a firing cartridge burns the gunpowder so completely that no analytical technique has yet been developed that consistently identifies the remaining trace quantities of unburned powder on the hands or clothing of the shooter. However, several procedures to accomplish this have been tried over the years. In the first attempts to associate an individual with a firearm, the hands were coated with a film of paraffin in order to lift off residual nitrites. This residue then could be visualized with diphenylamine.

This procedure was abandoned over 20 years ago, however, because nitrites do not provide sufficient specificity, and because large deposits are necessary to yield an adequate color development. Still, even today, many investigators erroneously refer to the “paraffin test” when discussing modern gunshot primer residue analysis.

Continued investigation into applications of neutron activation...
analysis identified two noncom‑
bustible primer mixture components,
barium and antimony, as detectable
residues from the discharge of most
ammunition. It was this discovery
that led to the reliable tests available
to the law enforcement community
today.

Procedure
In the most common analytical
protocol, cotton swabs moistened
with diluted nitric acid are wiped
over the web and palm areas of each
hand. Neutron activation analysis
(NAA) or atomic absorption spec‑
troscopy (AA) is used to determine
the quantities of barium and anti‑
mony on the swabs from both areas
of each hand. Since neither barium
nor antimony is unique to GSR, it is
necessary to find both elements in
amounts within the range found on
the hands of persons who are known
to have recently fired a weapon (a
control group).

In another method, techni‑
cians use adhesive disks to pick
up microscopic particles of GSR
from the hands. A scanning electron
microscope (SEM) equipped to con‑
duct energy dispersive X‑ray
analysis (EDXA) is used to detect
particles containing barium and
antimony. SEM‑EDXA produces a
visual image of particles, thereby
providing the analyst with useful
size and shape information. Addi‑
tionally, the barium and antimony
are shown to occur specifically
within these particles, as opposed to
being part of general background
contamination. This technique has
gained support in recent years due
to the development of automated
systems that simplify and eliminate
much of the lengthy and tedious
searching process.

There are variations and com‑
binations of these methods. How‑
ever, they all rely, at least in part,
on finding barium and antimony as
presumptive evidence of GSR.

Collecting Evidence
Gunshot primer residue is much
like chalk on the hands of a school
teacher using a blackboard. The
minute the teacher walks away from
the board, chalk loss starts through
mechanical actions, such as rubbing
the hands together, putting them in
pockets, rubbing them against cloth‑
ing, or handling objects. Therefore,
officers are instructed to collect GSR
evidence immediately upon making
an arrest. Generally, there is little
hope of finding adequate quantities
of barium and antimony to associate
an individual with a weapon after 3
hours of normal hand activities. And,
washing the hands removes essen‑
tially all GSR deposits.

Unfortunately, ideal GSR col‑
lection procedures are at odds with
the fundamental precept of immedi‑
ately handcuffing arrestees' hands
behind their backs. This cuffing
procedure can greatly decrease the
amount of GSR because the outer
webs of the hands are pressed
against the body. Any improper
procedures should be addressed by
arresting officers and crime scene
personnel since they could lead to
elimination or contamination of this
potentially valuable evidence.

GSR collection kits are avail‑
able at police supply stores and
through catalogs. The deceptively
simple appearance of these kits
implies that acceptable substitutes
can be made from standard drug‑
store items. However, this practice
can introduce multiple errors into the collection process. These errors can be avoided by using collection kits and questionnaires prepared commercially or by knowledgeable laboratory personnel.

**Important Points**

The real value of the GSR test is that it can associate an individual with a firearm. It is important, however, to note that this does not identify that person as the shooter. GSR can settle on any hand placed near a weapon as it is fired. A person can pick up GSR simply by handling a dirty weapon or discharged ammunition components. It is also possible, but very unlikely, that residue would be deposited on hands by other means. Thus, placing an individual in an environment of GSR generally puts that person in the presence of a firearm.

At the same time, failure to find GSR on the hands does not mean that a person tested did not handle or fire a weapon. For example, many test firings under controlled conditions in the FBI Laboratory do not deposit sufficient quantities of the material to allow identification. A firearm may produce deposits on five consecutive firings but not on the sixth. A weapon may simply not be sufficiently dirty or not handled enough to effect a transfer.

As noted earlier, GSR could have been deposited but later removed through washing or normal use of the hands. A finding of inconclusive amounts of barium and antimony simply means that the analyst can offer no opinion of value associating a tested individual with a firearm. The situation is analogous to a fingerprint analyst having no opinion concerning a particular person’s presence at a crime scene if print analysis is inconclusive.

The tests using neutron activation analysis (NAA) or atomic absorption spectroscopy (AA) for determining the total barium and antimony in each sample does not constitute an unequivocal identification of GSR. When elevated levels of both elements are found in a sample, the results are reported as being consistent with those obtained from persons known to have discharged a firearm. It is unlikely, but possible, to get independent environmental contamination of both elements in one or more of the four specimens collected from each person tested.

Barium and antimony can be found in trace amounts on most hands, and it is not uncommon to detect elevated levels in samples from a non-shooter’s hands. In a recent study, the FBI Laboratory analyzed samples from the hands of persons who had not been near a firearm. Of 267 sets of hand samples analyzed, 9 (3 percent) had significantly elevated levels of both elements and most of these were eliminated as being consistent with GSR by other parameters relevant to GSR tests.²

Analysis of GSR on the victim has little value in a suicide-homicide situation and should not be used routinely on the victim as an investigative tool. More gunshot residue goes out of the weapon’s barrel with the bullet than escapes near the handle. If the victim of a close range shooting attempt to grab the gun or instinctively shields the head, significant deposits can be left on the hands. Laboratory analysis cannot reliably determine whether the deposit was made in this manner or was the result of a self-directed firing.

Likewise, suspects at the crime scene should only be sampled if they do not admit to or cannot otherwise be associated with a weapon at the approximate time of the shooting. The person who just returned from a hunting trip or claims to have struggled with the victim (or assailant) over the weapon before the shooting, for example, generally should not be tested for GSR.

Accurate identification of GSR largely depends on the prior experiences of the laboratory performing the analysis to determine what is expected from specific areas of
the hands after handling weapons. Such information is not generally available, except for these specifically defined and studied areas of the hands. Thus, surfaces, such as automobile windows, clothing, and parts of the body other than these specific areas of the hands, are usually not suitable for GSR examinations.

Several factors can affect the analysis of unfamiliar surfaces, including environmental barium and antimony contamination and the potential for previous exposure to GSR. The latter concern is significant because GSR is not volatile and will generally remain on a surface until it is mechanically removed. Thus, GSR on the clothing of a suspected shooter can be explained by that person handling a weapon while wearing the garment several weeks earlier.

Conclusion

The detection of gunshot primer residue on the hands of an individual confirms that this person was in an environment of the material within a few hours preceding the collection of samples. This would likely result from firing a weapon, handling a weapon or ammunition, or being in close proximity to a weapon as it is discharged by another person.

Failure to detect GSR on the hands indicates that the test offers no information of value in determining whether an individual had been in the presence of the material. With the exception of very few well-defined situations, nothing more should be inferred from the results of GSR tests.

To avoid useless analysis, officers should not collect samples if:

- The person can be associated recently with a firearm by a witness,
- The hands were washed or more than a few hours have elapsed since the shooting,
- The ammunition used in the shooting does not contain both barium and antimony.

Setting these parameters saves time and eliminates much of the misunderstanding and confusion surrounding GSR tests. Like any analytical process, certain conditions must exist to ensure a useful GSR analysis.

Footnotes
