



Sergeant Suffers Sudden Cardiac Death While On Duty—Michigan

Executive Summary

On November 18, 2015, a 49-year old fire department sergeant (the “SGT”) working a 24-hour shift responded to one call in the afternoon. Upon returning to the fire station, the SGT became ill, vomited, and retreated to his bunkroom. He remained there the rest of his shift. When the next crew arrived at 0700 hours the next day, they found the SGT unresponsive in his bunkroom. A paramedic in the fire station checked the SGT. His vital signs indicated that he had been dead for several hours. The paramedic notified dispatch and medical control were notified. A medical examiner responded to the fire station and pronounced the SGT dead.

The death certificate and the autopsy report were completed by the Assistant Medical Examiner. The cause of death was listed as “hypertensive cardiovascular disease.” “Liver cirrhosis” was noted as a contributing factor. The SGT’s hypertensive cardiovascular disease was undiagnosed before this incident.

Key Recommendations

- *Provide annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for coronary heart disease (CHD)*
- *Perform symptom-limiting exercise stress tests (ESTs) on fire fighters at increased risk for CHD*
- *Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the components of NFPA 1582*

The following recommendations address general safety and health issues and would not have prevented the SGT’s death:

- *Perform an annual physical ability evaluation*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters*

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The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH Fire Fighter Fatality Investigation and Prevention Program, which examines line-of-duty deaths or on-duty deaths of fire fighters to assist fire departments, fire fighters, the fire service, and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with state or federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).



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Introduction

On November 19, 2015, a 49-year old career sergeant (the “SGT”) suffered cardiac death during the night while on duty at his fire station. NIOSH was notified of this fatality on November 20, 2015, by the U.S. Fire Administration. NIOSH contacted the affected fire department on November 24, 2015, to gather additional information and on January 19, 2016, to initiate the investigation. On February 8, 2016, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Executive Fire Commissioner
- Deputy Fire Commissioner
- Deputy Fire Chief
- Division Chief of Training
- International Association of Fire Fighters local President
- International Association of Fire Fighters local Secretary
- Crew members
- SGT’s family

NIOSH personnel reviewed the following documents:

- FD standard operating guidelines
- Death certificate
- Autopsy report
- FD medical evaluation records
- Primary care physician records
- FD self-contained breathing apparatus (SCBA) records

Investigation

On November 18, 2015, the SGT arrived at his fire station at about 0700 hours for his 24-hour shift, which began at 0800 hours. The SGT was assigned to Engine 33 but was working at Engine 48 this shift. Throughout the day, he performed paperwork and station duties. At 1552 hours, Engine 48 was dispatched to arcing electrical wires. The hazard was controlled upon their arrival and Engine 48 returned to quarters at 1610 hours. About 10 minutes later, the SGT became ill and vomited. He went into his bunkroom where he remained for the rest of his shift. Crewmembers checked on the SGT a couple of times, the last time being about 2000 hours. He did not have any additional complaints or concerns. The crew heard him cough periodically, and heard him speaking on his phone later that evening.

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The next morning, November 19, at about 0700 hours, crewmembers noticed the SGT was still in his bunkroom. They entered his bunkroom and found him unresponsive on the floor and not breathing. A paramedic in the station was summoned. The paramedic noted the SGT was cool to the touch with no respirations and no pulse. Concluding that the SGT had died earlier in the night, the paramedic did not attempt resuscitation. Dispatch was called and a medical examiner responded to the fire station. The medical examiner pronounced the SGT dead at 0715 hours.

Medical Findings

The death certificate and the autopsy report were completed by the Assistant Medical Examiner. They listed “hypertensive cardiovascular disease” as the cause of death. “Liver cirrhosis” was noted as a contributing factor.

The SGT had the following medical conditions:

Hypertension (Stage II) - first diagnosed in 2009 and began prescription blood pressure-lowering medication in 2009. Despite treatment, his blood pressure remained elevated; his last clinic reading on March 20, 2015 was elevated (155/97 millimeters of mercury [mmHg] [normal is 120/80 mmHg]). In November 2012, his blood pressure reached Stage II at 158/104 mmHg (Stage II is >160 mmHg systolic or > 100 mmHg diastolic).

Hyperlipidemia – first diagnosed in 2010 and prescribed a cholesterol-lowering medication in 2011. Despite treatment, his most recent (June 20, 2014) readings included an elevated blood cholesterol level of 250 milligrams per deciliter (mg/dL) (normal is < 200 mg/dL), a normal triglyceride blood level of 160 mg/dL, a normal low density lipoprotein (LDL) blood level of 100 mg/dL, and a normal high density lipoprotein (HDL) blood level of 120 mg/dL.

Fire Department

At the time of the NIOSH investigation, the fire department consisted of 38 fire stations with 1,350 career uniformed personnel. It served 700,000 residents in a geographic area of 139 square miles.

Employment and Training

The fire department requires all new fire fighter applicants to have a General Education Diploma/high school diploma and a state driver license; and pass a written exam, timed (6-minute) candidate physical agility test (CPAT) [IAFF, IAFC 2007], and background check. Newly hired fire fighters must then pass a preplacement medical evaluation (described below). Upon passing, they attend the 22-week fire fighter training course at the City Fire Academy. On completion, the candidate is certified as a Fire Fighter I and II, Medical First Responder, in Hazardous Materials (Hazmat) Awareness and Operations, driver’s training, and National Incident Management System (NIMS). Minimum state requirements include the 292-hour Fire Fighter I and II training, annual 4-hour hazardous materials operations training, and 12-hour NIMS training. New members are on probation for 6 months. They

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are placed on a 24-hour shift and work 24 hours on duty, 24 hours off-duty, 24 hours on duty, then are off 3 days (averaging 49 hours per week). The SGT was certified as a Fire Fighter II, Driver/operator, Fire Officer II, and in hazardous materials operations. He was promoted to SGT in December 2013 and had 23 years of fire fighting experience.

Preplacement Medical Evaluation

The fire department requires preplacement medical evaluations for all fire fighter applicants. The evaluations are conducted by a fire department-contracted physician. Components of the evaluation for structural fire fighter applicants include the following:

- Complete medical history
- Physical examination (height, weight, blood pressure, pulse, and respiratory rate)
- Complete blood count with lipid panel
- Urinalysis
- Urine drug screen (10 Panel)
- Audiogram
- Vision test
- Respirator use questionnaire
- Spirometry
- Resting electrocardiogram
- Chest x-ray (baseline)
- Pregnancy test (females only)

Once this evaluation is complete, the contracted physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the fire department's personnel director. Newly hired fire fighters receive an evaluation consisting of interval (any additional) medical history, blood pressure check, and an abbreviated physical examination of the chest, heart, ear/nose/throat, abdomen, and joints, and a hernia check. The SGT passed his preplacement medical evaluation in 1992.

Periodic Medical Evaluations/Return to Work Medical Evaluations

Annual medical clearance for fire fighting is required only for HazMat fire fighters. Other fire fighters receive a medical evaluation at promotion. These medical evaluations are conducted by a fire department-contracted physician. The evaluation include the following components:

- Complete medical history
 - Physical examination
 - Blood tests: complete blood count with differential (CBC), liver enzymes, cholesterol, and BUN/creatinine
 - Resting ECG
 - Chest x-ray
 - Urinalysis
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- Urine drug screen (10 Panel)
- Pregnancy test (females only)

The SGT's medical records reviewed by NIOSH did not contain records for a promotional medical evaluation in 2013.

Respiratory Protection

Annual self-contained breathing apparatus (SCBA) medical clearance is required for all fire fighters via a medical questionnaire, similar to that required by OSHA [CFR]. The questionnaire is reviewed by an occupational health nurse. An SCBA mask fit test is required annually.

Return to Work

Members injured on duty may be evaluated by the fire department-contracted physician or the member's primary care physician. Results of the evaluation are provided to the fire department-contracted physician, who makes the final determination regarding return to work. Members who are ill and miss 28 calendar days must be medically cleared to return to duty. Members off duty for 1 year or more must be medically cleared, then report to training division for an SCBA mask fit test, Fire Fighter I and II review, and an untimed physical ability test (contents are the same as the candidate physical ability test).

Wellness/Fitness Programs

The fire department does not have a comprehensive wellness/fitness program as recommended by the IAFF/IAFC Wellness Fitness Initiative [IAFF, IAFC 2008]. Fitness equipment (strength and aerobic) is available in most fire stations. The fire department provides exercise bikes and the members provide other equipment. An annual physical ability test is not required. The SGT did not exercise regularly, but did ride a bicycle occasionally.

Discussion

Sudden Cardiac Events

In the United States, atherosclerotic CHD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development are grouped into non-modifiable and modifiable. Non-modifiable risk factors include age older than 45, male gender, and family history of coronary artery disease. Modifiable risk factors include diabetes mellitus, smoking, high blood pressure, high blood cholesterol, and obesity/physical inactivity [NHLBI 2015; AHA 2016]. The SGT had two non-modifiable risk factors (age older than 45 and male gender) and three modifiable (high blood pressure, high blood cholesterol, and physical inactivity) CHD risk factors. Elevated liver enzymes, however, can affect the measurement and diagnostic value of the LDL and HDL tests [Salonen 2003; Hosoyamada et al. 2012; Jiang et al. 2014]. Despite these CHD risk factors, the SGT was not found to have "significant" atherosclerotic coronary artery disease at autopsy.

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The SGT's autopsy findings and his lack of angina, makes CHD an unlikely cause of his sudden cardiac death.

Left Ventricular Hypertrophy (LVH)

On autopsy, the SGT was found to have LVH. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. Because the autopsy reported minimal atherosclerotic coronary artery disease and normal heart valves, the SGT's LVH was probably due to his longstanding hypertension. LVH, one aspect of hypertensive cardiovascular disease, is associated with increased risk for sudden cardiac death [Levy et al. 1990].

Occupational Medical Standards for Structural Fire Fighters

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association (NFPA) developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2013a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The SGT had two conditions addressed by NFPA 1582: 1) poorly controlled Stage II hypertension and 2) beta-blocker medication.

Hypertension. The SGT fluctuated between Stage I and Stage II hypertension for many years. NFPA 1582 suggests that members with stage I hypertension be referred to their primary care physician to ensure that their blood pressure is controlled and to determine whether screening for end organ damage is indicated [NFPA 2013a]. The SGT's hypertension was diagnosed in 2009 and was poorly controlled with medication. He did not have a complete work-up for end organ damage. However, an EKG in 2013 found LVH, one type of end organ damage due to hypertension. LVH increases the risk of sudden cardiac arrest and sudden cardiac death [Koren et al. 1991]. The finding of LVH was not communicated to the FD physician, no further evaluation was done, and no restrictions were assigned.

NFPA considers that Stage II hypertension (systolic ≥ 160 mmHg or diastolic ≥ 100 mmHg) or end organ damage (retinopathy, nephropathy, neuropathy, or vascular/cardiac complications) compromises the member's ability to safely perform five of the thirteen essential job tasks [NFPA 2013a]. Therefore, according to NFPA 1582, the SGT should have been placed on work restrictions.

Beta-Blocker Medication. NFPA 1582 considers use of antihypertensive beta-blockers to compromise the member's ability to safely perform essential job tasks such as the following: 1) "wearing fire protective ensemble that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2°F;" and 2) "wearing personal protective ensemble and SCBA, climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces, and operating in proximity to electrical power lines and/or other hazards due to risk for dehydration, electrolyte disorders, lethargy, and disequilibrium, and the physician shall report applicable job limitations to the FD" [NFPA 2013a].

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Exercise Stress Tests (EST)

Recommendations on whether to screen asymptomatic individuals for CHD with EST are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic. On the basis of his medical conditions, the guidance overall indicates that SGT should have been on restricted duty (e.g., hypertension) or, at the very least, had further medical evaluation including an EST. If an EST had been performed, perhaps the SGT's hypertensive CHD would have been identified and he would have been referred for further evaluation and treatment.

NFPA

NFPA 1582, a voluntary industry standard, recommends an EST be performed “as clinically indicated by history or symptoms” and refers the reader to Appendix A [NFPA 2013a]. Items in Appendix A are not standard requirements, but are provided for “informational purposes only.” Appendix A recommends using submaximal (85% of predicted heart rate) ESTs as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (i.e., symptom-limiting) ESTs with imaging should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known CHD
- one or more risk factors for CHD (in men older than 45 and women older than 55)
 - Hypercholesterolemia (total cholesterol greater than 240 milligrams per deciliter)
 - Hypertension (diastolic blood pressure greater than 90 mm of mercury)
 - Diabetes mellitus
 - Smoking
 - Family history of premature CHD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).
- Framingham Risk Score > 10% [NFPA 2013a; ACC/AHA 2014]

CHD risk factors, and Framingham Risk Score of 10.3%, NFPA 1582 would have recommended a symptom-limiting EST.

American College of Cardiology/American Heart Association (ACC/AHA)

The ACC/AHA has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA guideline states that the evidence to conduct stress tests in asymptomatic individuals is “less well established” (Class IIb) for the following groups:

- persons with multiple risk factors (defined similarly to those listed by the NFPA)
- asymptomatic men older than 45 years and women older than 55 years:
 - who are sedentary and plan to start vigorous exercise
 - who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)
 - who are at high risk for coronary artery disease due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

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Given the SGT's public safety position, the ACC/AHA criteria suggest an EST would have been appropriate.

U.S. Department of Transportation

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial driver's license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic "high risk" drivers [Blumenthal et al. 2007]. The panel defines high risk drivers as those with any of the following:

- diabetes mellitus
- peripheral vascular disease
- age 45 and above with multiple risk factors for CHD
- Framingham risk score predicting a 20% CHD event risk over the next 10 years

The SGT was over age 45 and had multiple risk factors for CHD suggesting the U.S. Department of Transportation would have recommended an EST for a commercial truck driver with a similar profile [Blumenthal et al. 2007].

U.S. Preventive Services Task Force (USPSTF)

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for CHD events. For individuals at increased risk for CHD events, the USPSTF found "insufficient evidence to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning..." Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 2004]. The USPSTF does note that "For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit to the individual patient may influence the decision to screen for coronary heart disease."

Recommendations

Recommendation #1: Provide annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for CHD.

Discussion: Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2008; NFPA 2013a]. Although the FD is not legally required to follow the NFPA standard or the IAFF/IAFC guideline, additional steps could be taken to ensure the medical ability of fire fighters to perform duties without presenting a significant risk to the safety and health of themselves or others.

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Recommendation #2: Perform symptom-limiting ESTs on fire fighters at increased risk for CHD.

Discussion: Firefighters with multiple or severe CHD risk factors, or a Framingham risk score > 10%, are at increased risk of a sudden cardiac event [ACC/AHA 2014; AHA 2014]. The fire department does not screen members for CHD risk factors, and does not conduct aerobic capacity tests or ESTs to determine whether fire fighters are at increased risk for a sudden cardiac event.

Recommendation #3: Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Discussion: According to NFPA 1582, the fire department should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2013a]. The physician should review job descriptions and essential job tasks required for all fire department positions. The physician must understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. Although the fire department allows the member's personal physician to clear fire fighters who miss work due to injury/illness, it requires that all personal physician clearances be reviewed by the fire department-contracted physician. NIOSH investigators commend the fire department for requiring this step because personal physicians may be unaware of the hazardous and physical demands of structural fire fighting and the guidance provided by NFPA 1582.

The following recommendations address general safety and health issues and would not have prevented the SGT's death:

Recommendation #4: Perform an annual physical ability evaluation.

Discussion: NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the FD to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013b]. Once developed by the FD, this evaluation could be performed as part of the FD annual training program.

Recommendation #5: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Discussion: Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and in Firefighter Fitness: A Health and Wellness Guide [IAFF, IAFC 2008; NFPA 2008; Schneider 2010]. Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Pelletier 2009; Baicker et al. 2010]. Fire service health

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promotion programs have been shown to reduce coronary artery disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006; Poston et al. 2013]. A study conducted by the Oregon Health and Science University reported a savings of more than \$1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl et al. 2013].

The fire department does not offer a wellness/fitness program. However, exercise equipment is available in the fire stations; much of which was purchased by the members. NIOSH recommends a formal, mandatory wellness/fitness program. The program should ensure all members can receive the benefits of a health promotion program and have the ability to exercise on similar equipment no matter where they are assigned.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician. Dr. Thomas Hales (MD, MPH) provided medical consultation and co-authored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Health, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

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Appendix A Autopsy Findings

- Hypertensive heart disease
 - Mild cardiomegaly (upper range of normal) (heart weighed 450 grams [g]; predicted normal weight is 358 g [ranges between 271 g and 473 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
 - Left ventricular hypertrophy
 - Left ventricle and its wall thickened (1.6 centimeters [cm])
 - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
 - Normal by echocardiographic measurement is 0.6–1.0 cm [Connolly and Oh 2012]
 - Papillary muscles and cordae tendineae thickened
 - Cardiomyocyte hypertrophy and interstitial fibrosis on microscopic examination
- No significant atherosclerotic disease of the coronary arteries
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Cirrhosis of the liver
 - Enlarged liver (2525 grams)
 - Normal is 1000-1500 grams [Ghany and Hoofnagle 2008]
 - Extensive steatosis
- Renal glomerulosclerosis and arteriosclerosis on microscopic examination
- Negative blood test for drugs and alcohol

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