“It’s a patient, not just a sample.”

Author unknown

In veterinary medicine, as in human medicine, doctors have become more dependent on laboratory results. Lisa Sanders, MD, of the Yale School of Medicine, quipped that medical doctors look at laboratory values as “coming straight from god.” Although this statement is an exaggeration, it does suggest the degree of importance placed on laboratory data. It also emphasizes the level of responsibility placed on medical laboratory professionals in human medicine and, by extension, on the veterinary healthcare team (VHCT) and their clients in veterinary medicine to obtain reliable results.

But not only the sample collection and handling portions of the preanalytical process influence laboratory results. Everything from client education and VHCT preparedness to patient “state of mind” to clinical facilities and beyond may also affect the reliability of results. This article addresses the latter factors.

With the patient as the primary focus, the laboratory process has been divided into 3 related stages: preanalytical, analytical, and postanalytical (BOX 1).

“…do no harm…”

The Hippocratic Oath

In multiple studies in human medicine,3,4 and in anecdotal information and one study found in veterinary medicine,5 most challenges to reliable results were traced to the preanalytical phase. Although this is the most common phase for challenges, it is frequently where they are simplest to control.6,7 In human medicine studies, the results varied. The total error in the human regulated laboratory process was approximately 0.1% to 9.3% in one study4 and 0.1% to 3% in another.3 The effects of these errors ranged from inconsequential to life-threatening. Approximately 31% to 75% of the errors were traced to the preanalytical phase of the laboratory process.3,8 One recent study in human medicine suggests the distribution of errors among the phases may be changing, based on its finding that an increasing number of errors in the analysis phase are due to operator error.9

With rare exceptions (e.g., equine infectious anemia testing),10 there is no government-required external oversight system for the veterinary point-of-care (POC) laboratory. The amount of error in the veterinary POC laboratory is unknown, but it is predicted to be similar to that in...

human medicine.\textsuperscript{11,12} Although the overall percentage of errors seems low, for an affected patient and client, any error is still important.

**THE NEED FOR RELIABLE RESULTS**

The goal of every laboratory, whether POC or off-site, is to provide reliable results and excellence in patient care. Reliable results, by definition, are both accurate and precise. In this context, accurate means that they are truly representative of the patient’s values, whereas precise means that they are repeatable.\textsuperscript{7,13}

Reliable results aid the entire VHCT in delivering the best possible:

- Routine health screenings (e.g., geriatric, presurgical, initial, and annual visits)
- Diagnoses
- Prognoses
- Treatments
- Patient monitoring
- Development and maintenance of patient-specific baselines
- Development and maintenance of practice-specific reference intervals
- Forensic evidence

**BOX 1 Phases of the Laboratory Process**

<table>
<thead>
<tr>
<th>Preanalytical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client request for in-clinic or ambulatory services</td>
</tr>
<tr>
<td>Client education</td>
</tr>
<tr>
<td>Patient identification, preparation, transport, history, and physical examination</td>
</tr>
<tr>
<td>Sample collection, labeling, handling, and preparation for test</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analytical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance of tests</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postanalytical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reporting of results</td>
</tr>
<tr>
<td>Review of values and possible anomalies</td>
</tr>
<tr>
<td>Diagnosis</td>
</tr>
<tr>
<td>Client education</td>
</tr>
<tr>
<td>Process review</td>
</tr>
</tbody>
</table>

**STEPS TOWARD RELIABLE RESULTS: QUALITY ASSURANCE, QUALITY CONTROL, AND STANDARD OPERATING PROCEDURES**

To ensure reliable results, it is necessary to have a quality assurance (QA) program that sets the planning, implementation, education, monitoring, and assessment parameters for the entire process—preanalysis through analysis to postanalysis. This is commonly accomplished through the development and use of protocols and standard operating procedures (SOPs). Integral to the analysis phase of QA are quality control (QC) procedures that commonly use a commercially available substance, or “control,” of known value that is similar to and treated in the same manner as the patient sample. It is assumed that,
barring unforeseen circumstances, if the control results provided by the manufacturer are achieved, the patient results will also be correct for the specific test.12,14,15

To minimize the effects of personal differences on reliability of results, standardization of procedures is necessary. Written SOPs provide a foundation for communication and control of the entire process. For SOPs to be effective, all members of the VHCT must buy into them. To minimize drift, all members of the VHCT must be initially and periodically educated, updated, observed, and evaluated in the use of the SOPs. The SOPs must provide the who, what, when, where, and why in addition to the how of each procedure performed in the process. SOPs must be periodically reviewed, with adjustments made only when a valid need arises.12,14

Veterinary practice and consumer protection regulations, standards of practice, and/or professional ethics may state or imply the need for quality in all aspects of practice. To this end, throughout the laboratory process, regardless of whether tests are performed in a POC or off-site laboratory, the primary responsibility lies with the VHCT to prevent or catch potential issues that may cause errors. Inaccurate results are worse than no results!16

SMALL STUFF MATTERS

In his book An Astronaut’s Guide to Life on Earth: What Going to Space Taught Me About Ingenuity, Determination, and Being Prepared for Anything, Canadian astronaut Col. Chris Hadfield acknowledges that not only large, obvious issues but also small, seemingly unimportant, and easily overlooked matters can be detrimental to a mission.17 This lesson can be applied to the “mission” of veterinary medicine as well. Just as in a space mission, recognizing and avoiding pitfalls in clinical pathology and associated laboratory processes can go a long way toward ensuring reliable results and preventing potential harm to the patient.

Many challenging factors in clinical pathology can negatively influence the validity of results. Some are external to the patient; others are patient-specific but may or may not be related to the patient’s particular medical condition or health screening. They can mistakenly cause:

→ Test results that should be negative to be positive, or results that should be positive to be negative
→ Values that should be low to be high, or those that should be high to be low
→ Values that should be outside of the reference interval or baseline for the patient to be within the reference interval or baseline, or values that should be within the interval or baseline to be outside it

Another confounding element is when, based on the control, patient results are assumed reliable for the specific sample obtained and tests conducted but do not meet expectations. These results warrant additional investigation and should not be automatically assumed to be errors. Some common sources for these apparent contradictions are listed in BOX 2.

BOX 2 Common Reasons for Unexpected Laboratory Results6,9,12,18

→ “Snapshot-in-time” phenomenon: results are representative of the patient at the time of collection, but have been skewed by an influencing factor (e.g., excitement, sedation) with a very short-term effect
→ Lack of characteristic signs of a medical condition
→ Presence of disease that is new to the geographic area
→ Individual physical, physiologic, and/or psychologic factors that are not characteristic of the patient’s species, breed, or strain
→ Insufficient patient history
→ Lack of DVM order for and/or performance of a relevant test
→ Test methodologies that lack specificity and/or sensitivity
→ Differences in reporting methods
→ Human (client/VHCT) factors
→ Environmental influences
→ Expectation that all values within the reference interval for the patient’s reference group are “normal” and those that are outside are “abnormal,” or vice versa
→ Patient or sample mix-up
→ Unknown, forgotten, or perceived “unimportant” details
An additional challenge is the apparent lack of availability of practical QA and QC information and of initial and continuing education for POC QA and QC. Much of the available information has been developed for veterinary reference and commercial laboratories, extrapolated from the regulated human medical field, passed on by word of mouth, or gleaned from commercial marketing rather than technical materials. Caution must be used with these sources of information, which may not be complete or specific for a particular POC situation.\textsuperscript{8,11,12}

**PEOPLE ARE IMPORTANT**

“High-tech,” “new and improved,” and “quick and easy” are not synonymous with reliability. Nor can technology use suboptimal samples to achieve reliable results.

The human elements of experience, knowledge, observation, ability, integrity, intuition, communication skills; recognition of strengths and limitations; and empathy for the patient and client are necessary to achieve the desired outcome.\textsuperscript{19}

Most VHCT members would probably agree that there are areas in our professional and home lives in which we feel more comfortable, based on our level of knowledge and abilities. Most likely, we also recognize the information explosion that surrounds us in both settings and the need to keep up with the times to the best of our abilities in as many areas as possible. To this end, we find ourselves attaining different levels of expertise based on the needs and demands of these two “lives”:

- **User**: obtains reliable results when performing a procedure
- **Operator**: user + “understands” the basic principles of the procedure
- **Specialist**: operator + evaluates reliability of results, process, and user/operator; makes appropriate changes, “repairs,” and corrections with minimal, if any, assistance\textsuperscript{17}

**EVERYTHING INFLUENCES SOMETHING**

The factors that influence the preanalytical phase can be divided into 6 categories:
- VHCT
- Client
- Patient
- Environment
- Sample collection
- Sample handling and processing

This categorization demonstrates the range of the preanalytical phase. All the parts are interrelated and, in turn, are influenced by pathologic and/or nonpathologic variables. The scope of this phase is likely one of the major reasons the preanalytical clinical pathology phase is considered to have the greatest number of influences on the reliability of results.

**THE GOAL: PATIENT-CENTERED CARE**

Patient-centered care is a team-based approach that includes the patient, client, and all members of the VHCT. The goal of patient-centered care is to foster a communicative, sharing, and collaborative relationship to specifically meet the patient’s needs. The clinical pathology part of this approach is to provide the “right test, to the right patient, at the right time,” culminating in reliable results and excellence in patient care.\textsuperscript{2,20}

By initially addressing the patient, client, environmental, and nonpathologic biologic variables, we set the stage to be better prepared for the actual collection and sample handling procedures. Ensuring that the client is on board, gathering the appropriate information about the patient, and having the necessary materials and VHCT members available help to expedite the process.

**COMMUNICATION IS KEY**

“I know that you believe that you understood what you think I said, but I am not sure you realize that what you heard is not what I meant.”

Attributed to Robert J. McCloskey, Spokesman, US State Department, at a Vietnam War press update

As people, we are all different because of our varied experiences, education, knowledge, interpersonal interactions, and capabilities. These differences, more often than not, are a great benefit. To ensure they will be an advantage lies in our ability to communicate and have a mutual understanding.\textsuperscript{19}

**Within the Veterinary Healthcare Team**

The information veterinary technicians attempt to gain from or share with clients or other members of the VHCT depends on several communication influences:
What is said and not said: Reading between the lines
How it is said: Interpreting the attitude of the interaction/transmission of information (e.g., perceived level of interest, facial expression, eye movement/contact, voice inflection/tone/volume, vocabulary/grammar, professionalism of appearance and behavior)
Means of transmission: Oral (e.g., instruction, question, conversation), written, visual, audiovisual, demonstration, telephone, text, e-mail
Individual state of mind during and between transmission and use of information
Level of comprehension
How, when, and from whom the information was obtained
Other variables (e.g., ability to hear, regional accent, speech impediment, distractions)21–23

With the Client
The veterinary–client–patient relationship assists the client in being an “active” partner in all processes with the VHCT. In turn, it helps the client to make informed decisions based on the recommendations of the VHCT. For the client to be informed sufficiently to make these decisions and the VHCT to be prepared for the patient, clients must be educated at the point of first contact, thus initiating an ongoing process of communication.24 Client knowledge and compliance are related to an understanding of the patient’s needs and the abovementioned communication influences. BOX 3 describes a recommended approach to obtaining information from clients; BOX 4 lists the basic information that VHCT members should provide in turn.

“I hear and I forget.
I see and I remember.
I do and I understand.”
Paraphrase, attributed to Confucius

To reinforce and supplement verbal communication and help improve client compliance, VHCT members can use practice-prepared written/visual materials, practice-reviewed and approved outside/commercial information, and/or practical demonstration. If it will be necessary for the client to perform a procedure in the home environment, it may be prudent to observe the client’s ability to do so. In addition to on-site and telephone communication, it may be appropriate to use texting, e-mail, and websites with practice-prepared and/or practice-reviewed and approved information.21–23

THE TOTAL PATIENT
Behavioral Factors
A knowledge of the patient’s innate and learned behaviors, likes and dislikes, and types of responses to different stimuli can assist veterinary technicians in providing the

BOX 3 Suggested Approach to Acquiring Client Information21–23

Know what information must be obtained from or transmitted to the client before the conversation (who, what, where, when, why, how)
Identify the services the client perceives to be necessary for the patient (e.g., presenting complaint, preventive care)
Use open-ended questions to stimulate the client to consider the issue and subsequently answer in a more complete manner, providing facts, not opinion or interpretation
Use follow-up questions to clarify information; these questions may be short-answer (e.g., yes or no) questions
Avoid interrupting the client unless time is critical and/or they have veered off topic
Provide the opportunity for the client to ask questions and to add free-form pertinent information
Document what information has been requested and received
best possible experience and the least amount of discomfort, stress, and excitement for the patient, client, and VHCT alike.

Regardless of patient size or species, negative and positive sensory (e.g., sight, smell, taste, sound, touch, pain, temperature, balance) experiences form a basis for the patient’s memory of people, places, and things. These experiences can be associated with transport, a new environment or the presence of other patients, a procedure, or even a hearty welcome from a VHCT member, and any of these events may initiate a patient response.

Whether immediate or long-term, patient stimuli can result in stress, causing the release of glucocorticoids, and/or excitement, resulting in the release of epinephrine. Even though the initiator of the stress or excitement is not necessarily bad, the influences on laboratory values may be confounding, resulting in alterations such as hyperglycemia, glycosuria, leukocytosis, and neutrophilia.6,9,25–28

**BOX 4 Common Information to Provide to Clients**

The order of information to be disseminated may vary with the circumstance.

- The client’s expected role, including unique situations (e.g., need to collect samples or administer sedatives at home)
- Special patient care required before sample collection (e.g., fasting, special diet, minimizing excitement)
- Additional information the client will need to provide at the clinic or ambulatory visit (e.g., history, presenting complaint)
- After the veterinarian evaluates the patient and orders the tests to be performed:
  - Types of samples required
  - What procedures will be performed during sample collection (e.g., clipping an area for a venipuncture)
  - Why the tests are being performed
  - How the information obtained from the test will help the veterinarian to help the patient
  - When results will be available
  - Costs involved

**Environmental Factors**

Environmental factors such as a cold table, slippery surfaces, the noise of a fluorescent light, the bang of a gate or cage door, and differing amounts or varying patterns of light can be confusing and physiologically and psychologically stimulating to some patients. Other environmental factors can be of a geographic nature. Patients living in areas of higher altitude or poorer air quality may have higher packed cell volume and hemoglobin levels. Patients in transient situations may have a greater chance of exposure to diseases not native to their home environment.

Like us, our patients acclimate physically, physiologically, and psychologically to circumstances, tend to have a long memory, and are more likely to respond positively to quiet handling and consistent, low-key, complementary environments.6,7,11,22–24,26

Regardless of the term used to describe it—patient-centered, low-stress, humane, Fear Free™, genuine care and concern for the individual, kinder–gentler—minimizing patient stress and excitement and that of the associated humans can lead to more reliable results and excellence in patient care.6,7,11,22–24,26

**Physical Factors**

**BOX 5** lists nonpathologic physical characteristics that should be observed for every patient.

Acquired identification characteristics and signalment assist in the positive identification of the patient and sample and the retrieval and update of patient and client records. The signalment may also help support or eliminate conditions associated with a particular species, breed/strain, age, gender, genotype, or other inherited/congenital characteristics. These characteristics also may help to determine what methods may be used in patient care (e.g., handling, restraint, sample collection).

In addition to contact information, client qualifiers may assist in identifying issues related to the patient’s medical condition. For example, the location may assist in detecting disease associated with a specific geographic area.

Having multiple members of the VHCT examine and observe the patient not only allows for efficient gathering of information but also minimizes the chance of missing a patient characteristic. The typical observation points may provide a link to confounding influences such as a possible medical condition, iatrogenic characteristics, or “white-coat syndrome” factors (e.g., stress, excitement).6,8,27

**The Other Somethings**

Patient identifiers, demographics, and other influences such as those listed in **BOX 6**, as well as how much, when,
and how a patient has been exposed to each, may affect the patient and, subsequently, its laboratory results. Regardless of whether there is a noticeable effect on the patient, the test results still may be affected. Even circumstances that are perceived as “typical” or “good” for the patient may influence test results.

The effect of these in vitro and/or in vivo influences on laboratory values may result in relative or absolute increases or decreases in the amount of an analyte and/or chemical or physical changes that interfere with the test procedure. The effects may be due to acute or chronic influences, and there is no accurate way of determining in all situations how values may be altered. Patients are individuals, and their responses may be different.2-5,8,27

**CONCLUSION**

This is only the beginning of the preanalysis phase. It continues through a multiplicity of procedures involving the patient, as well as sample collection and handling.

As much as possible, communicate, standardize through SOPs, and use QA programs and QC procedures to monitor the entire process.2-5,8,27

---

**BOX 5 Nonpathologic Physiologic Patient Identifiers**

<table>
<thead>
<tr>
<th>Acquired Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ Name, number</td>
</tr>
<tr>
<td>→ Tag, collar, brand, implant, tattoo, notching</td>
</tr>
<tr>
<td>→ Acquired characteristics (e.g., dehorning, docked tail, ear cropping, scars)</td>
</tr>
<tr>
<td>→ Associated client information</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signalment</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ Species</td>
</tr>
<tr>
<td>→ Breed/strain</td>
</tr>
<tr>
<td>→ Age/date of birth</td>
</tr>
<tr>
<td>→ Gender, including neuter status, intersex</td>
</tr>
<tr>
<td>→ Color (e.g., coat color, eye color)</td>
</tr>
<tr>
<td>→ Inherited and congenital characteristics; genotypes (e.g., identity/disease susceptibility)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Examination Findings and Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ Veterinary technician observations (at minimum)</td>
</tr>
<tr>
<td>→ Types of samples required</td>
</tr>
<tr>
<td>→ Temperature, pulse, respiration, skin turgor</td>
</tr>
<tr>
<td>→ Mucous membrane color, moistness, capillary refill time</td>
</tr>
<tr>
<td>→ Weight, body condition score</td>
</tr>
<tr>
<td>→ Temperament</td>
</tr>
<tr>
<td>→ Overall appearance, posture</td>
</tr>
<tr>
<td>→ Veterinarian examination</td>
</tr>
</tbody>
</table>

---

**BOX 6 Examples of Demographic and Patient Factors That Can Influence Laboratory Results**

| → Client (e.g., initial information provided) |
| → Preventive care (e.g., vaccines, parasiticides, physical examination) |
| → Diet, feeding/watering regimen (e.g., changes, amount, communal or individual, free choice or intermittent, source, brand), changes in appetite, treats or snacks, fasted |
| → Environment (e.g., geographic location, season, diurnal variations, travel, weather, air quality, biohazards, biosecurity, biocontainment practices, toxin exposure) |
| → Bowel movements and urination (e.g., frequency, volume, changes, description) |
| → Association with other animals (e.g., domestic, wild, vermin) or insects; health status of other animals; new arrivals |
| → Emesis, drooling, discharge (e.g., frequency, amount, contents, color, transparency, consistency) |
| → Association with people and their health status, travel history, association with animals |
| → Medication history (e.g., prescription, over the counter, compounded, supplements, vitamins, minerals, anthelmintics, alternative, source, brand, dose, dosage regimen, means of administration, responses) |
| → Temperament, behavior, typical versus atypical |
| → “Lifestyle” or function (e.g., pet, production animal), amount and type of activity (e.g., exercise, “work,” pregnancy) |
| → Medical/surgical history |
Preanalytical Small “Stuff” That Influences Reliable Laboratory Results

References