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The impact of automating laboratory request forms on the quality of healthcare services

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Summary In recent decades, healthcare organizations have undergone a significant transformation with the integration of Information and Communication Technologies within healthcare operations to improve healthcare services. Various technologies such as Hospital Information Systems (HIS), Electronic Health Records (EHR) and Laboratory Information Systems (LIS) have been incorporated into healthcare services. The aim of this study is to evaluate the completeness of outpatients' laboratory paper based request forms in comparison with a electronic laboratory request system. This study was carried out in the laboratory department at King Abdulaziz Medical City (KAMC), National Guard Health Affairs, Riyadh, Saudi Arabia. We used a sample size calculator for comparing two proportions. We estimated the sample size to be 228 for each group. Any laboratory requests including paper and electronic forms were included. We categorized the clarity of the forms into understandable, readable, and unclear. A total of 57 incomplete paper forms or 25% were identified as being incomplete. For electronic forms, there were no incomplete fields, as all fields were mandatory, therefore, rendering them complete. The total of understandable paper-based laboratory forms was 11.4%. Additionally, it was found that the total of readable was 33.8% and the total for unclear was 54.8%, while for electronic-based forms,

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there were no unclear forms. Electronic based laboratory forms provide a more complete, accurate, clear, and understandable format than paper-based laboratory records. Based on these findings, KAMC should move toward the implementation of electronic-based laboratory request forms for the outpatient laboratory department.

Introduction

Today, many hospitals have implemented or are planning to implement information technology systems and solutions to improve the quality of services provided to patients. In Saudi Arabia, the uptake of technology has lagged compared to more industrialized nations. Some Saudi institutions are leading, while others are lagging in the implementation of Hospital Information Systems. For example, King Faisal Specialist Hospital and Research Center (KFSH-RC), in Saudi Arabia has reached stage 6 for the Electronic Medical Record Adoption Model (EMRAM), while other hospitals still use paper records.

One healthcare domain that has benefited from the use of information technology has been the laboratory department. Although the literature shows that the use of information technology can enhance the process of healthcare delivery, many hospitals in Saudi Arabia continue to use paper-based forms when ordering lab tests [2—4]. The process of requesting lab investigations for outpatients usually occurs manually through paper-based forms. The requesting physician fills the paper form and hands the form to the patient in order to deliver the hardcopy manually to the laboratory receptionist. Afterwards, the lab technician draws the blood samples from patients, attaches the paper form to the acquired samples, and sends them to the central lab for further study and analysis (See Fig. 1).

Many clinicians cannot be expected to stay up-to-date with every complex test and diagnostic procedure outside their specialty. Furthermore, the overcrowded environment at the lab reception slows down the workflow and influences the quality of clinical care provided to healthcare customers [1,5]. Appropriate implementation and the use of laboratory electronic form test-requesting systems can help overcome many of the aforementioned challenges [2,3,5].

Research studies have been conducted on the computerization of Laboratory Information Systems and their impacts on the organizational workflow [2—6]. Other studies investigated the impact of incomplete data and its influence on patient diagnosis and treatment [3,4]. Based on the literature, laboratory workflow processes can be improved with the adoption of electronic laboratory forms as compared to the use of manual paper forms [2,5]. Some studies focused on the influence of missing crucial clinical parameters on the interpretation of laboratory results and the reporting of patient diagnosis [1,5].

One study focused on determining the category and regularity of errors when providing data on laboratory request forms at a hospital in Nigeria. The analysis included an assessment of the application forms, to determine incorrect or incomplete sections of the application form, and the regularity or frequency of errors. Most of the data omitted and/or regularly repeated in the laboratory forms was patient age and their location, the name of attending physician, and information regarding patient's gender. Further, audited laboratory request forms did not have enough information about the diagnosis or the type of the clinical sample. The authors emphasized the dangers of incomplete laboratory request forms that included misdiagnosis and mismanagement of patients leading to deteriorating health among patients. They suggest that laboratory request test forms should be completed to avoid issues in the healthcare systems such as misdiagnosis, repeated laboratory test and improper treatment procedures [8]. Another study collected examples of medical error cases which were a result of missing names, times, and medical record numbers. These inadequacies of missing data lead to incorrect diagnosis and an increase in the number of medical errors within the hospital [3,4]. One study compared handwritten laboratory test-requests with electronic Laboratory Information Systems. The authors identified the types and numbers of errors that existed in handwritten serology test requests received in outpatient clinics. The results showed that the written request forms had 67 out of 627 errors where 51 of these errors were transcription faults while 10 were associated with abbreviations. The study concluded that written data-entry of serology requests is a process that is prone to many mistakes. The authors suggest the use of electronic ordering because it has the potential to eliminate handwritten and

transcription errors and improve data accuracy in hospital information [10].

Another study evaluated pre-analytical errors with inadequacies in the completion of laboratory requisition forms. The study involved an assessment of original laboratory request forms received at the department of clinical biochemistry for four months. The evaluation included a manual inspection of the presence of pre-fixed criteria. 56,000 requisition forms were assessed, and it was found that the most inappropriately filled parameter was information regarding specimens, treatment, and clinical data, which were missing in almost all the forms reviewed. Nevertheless, the relevant clinical notes were clearly stated in 74.6% of the forms while the patient's information was mostly filled correctly. The findings emphasized the need to enforce and implement policies that would enhance accuracy and compliance with the necessities of laboratory request form completion.

In 2006, Plebani conducted a study focused on laboratory errors that occur frequently during the delivery of laboratory testing. Most of these errors occurred during the pre-analytical and post-analytical stages of the laboratory test. The author discusses that these errors interfere with clinical diagnosis. The author discusses that the mistakes made in the Total Testing Process (TTP) are laboratory related and may have been caused by poor communication, actions taken by nurses or physicians involved in the testing process, or poorly designed testing processes. Furthermore, evidence shows that lab information is partially used, which may contribute to further errors. The study is focused on providing a description of the most frequent and risky pre-, intra-, and post-analytical errors and provides advice on the practical methods of measuring and reducing the risk of mistakes [9].

In 2015, Muluberhan conducted a study examining the significance of laboratory request forms in assisting the performance of all laboratory tests to the benefit and satisfaction of all laboratory users. The authors assessed the content of empty request forms and evaluated the completeness of filled information on medical laboratory request forms, and the communication of results to users in two different hospitals. The study showed that the standard of request forms was weak considering that essential information required was not provided by the requester, — leaving many gaps in the provided information. This affected the provision of clinical advice based on the limited information available on the request forms which increased potential errors. The study confirms that all required parts of the request forms should be completed to provide sufficient information needed to establish laboratory diagnosis, enhance patient care, save time and financial resources [7].

In 2013, Wiwanitkit found that significant errors in the request forms were mainly due to incomplete information and the use of non-standard abbreviations. Many errors were also observed during the collection of specimens, diagnosis, and patient identification. The study concludes that the major fault of the laboratory requests was incomplete request form writing and suggests that medical personnel should ensure accuracy in specimen collection and writing request forms [11].

Many studies discussed the implementation and the use of electronic laboratory request forms and show a clear advantage in the use of electronic over paper-based laboratory request forms. However, there have been few studies comparing paper and electronic-based laboratory forms in Saudi Arabia. Most of available studies evaluated completeness, without measuring clarity, where clarity is defined as data that is understandable, readable, and clear. Especially in Saudi Arabia, where English is a second language, the possibility of unclear data entry into English laboratory forms becomes a risk for higher incidence of medical errors.

The main objective of this study is to evaluate the completeness of outpatient laboratory paper-based request forms in comparison with electronic laboratory request system, is to provide an in-depth

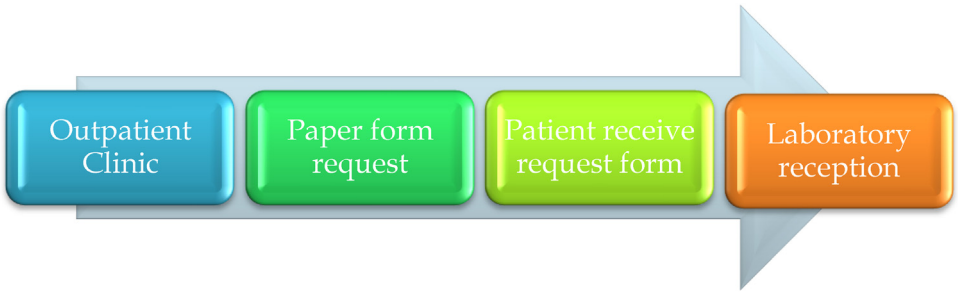

Figure 1 Laboratory paper form workflow at KAMC-RD.

overview of the data quality, accuracy and completeness on both systems. Furthermore, there are some secondary objectives, which are: (1) To evaluate the completion of information on laboratory examination request paper forms in comparison to electronic form, (2) To evaluate the clarity of the requesting physicians information in comparison to electronic forms, (3) To evaluate the completion of all required fields on the paper forms in comparison to electronic forms and (4) To evaluate unauthorized modification of information on paper forms in comparison to electronic form.

Methods

Study setting

The study was carried out in the laboratory department at King Abdulaziz Medical City (KAMC), National Guard Health Affairs. The laboratory department consists of four units, anatomical pathology, clinical chemistry, immunopathology, and toxicology. KAMC is metropolitan hospital that is based in Saudi Arabia with a combined capacity of approximately 1500 beds. Since 2013, KAMC began to enter lab requests into the Laboratory Information System, for inpatients only. For outpatients, it remains a paper-based form. Our study compares the inpatient electronic request forms with the paper-based outpatient forms.

Sample

We used a sample size calculator for comparing two proportions. Using a 95% confidence interval, we estimated the sample size to be 228 for each group. Any laboratory requests including paper and electronic forms were included. When collecting the total 456 electronic and paper forms, all forms were selected randomly by using a randomizer website. Furthermore, we introduced exclusion and inclusion criteria. The study included laboratory request forms in the inpatient and outpatient setting within KAMC-RD and excluded: (1) Lab paper-form requests from outside KAMC-RD; (2) Interns and less than one-year trainees; (3) visiting or locum staff, to ensure a consistent awareness level of staff on both paper and electronic forms.

Data extraction and collection

This study assessed hand-written outpatient laboratory request forms for a three-month period beginning on March 1, 2015 and ending on May 31, 2015. The method of collecting data was to acquire the information from laboratory forms at the laboratory reception area. All laboratory request forms from different clinics are transferred to the laboratory. It took an average of 10 min to apply the coding scheme to each of the laboratory forms. The laboratory form contained ten primary sections: (1) physician information; (2) patient information; (3) diagnosis; (4) Hematology; (5) Chemistry; (6) Serology; (7) Microbiology; (8) Flow cytometry; (9) Blood Bank; (10) Miscellaneous. See Appendix A for a sample lab form.

Classification of errors

A researcher independent from the laboratory, but working within the hospital as a biomedical engineer, audited the contents of the handwritten request and electronic forms associated with each request and classified the errors into categories as shown in Table 1.

A secondary researcher audited the work of the primary researcher to improve the reliability of the results. Any disagreements were discussed until consensus was reached.

Ethical considerations

The study was approved by KAIMRC and no informed consent was required, as the researchers were only reviewing paper and electronic forms. We ensured that none of the patients were identified and that care was taken in retrieving and returning any of the paper-based forms used. No patient or physician-related information was collected. Data retrieval and analysis began after receiving Institutional Review Board (IRB) approval from King Abdullah International Medical Research Center in November of 2015.

Data analysis

Data analysis was carried out by using descriptive and the chi-square test through statistical package for social sciences (SPSS) version 21.

Results

Table 2 shows the total number of errors recorded for both the electronic and paper-based forms. Any field within the electronic and paper-based form that was completely missing was counted as an error, and the whole form was flagged as incomplete. A total of 57 (25%) incomplete paper forms were identified. For electronic forms, there were no incomplete forms, as all the fields were

Table 1 Coding scheme.

Error type	Definition	Example
Understandable	The form provides a decent knowledge about written fields	Found patient with anemia, sample blood for CBC
Readable	The form is clear to read in hand writing and provides no knowledge	Vit D and Basic Screen
Unclear	The form is unreadable and cannot extract information	The jdshncsl (unclear handwriting)

Table 2 Completion of forms (overall errors rate).

Record type	Complete	Incomplete	Total
Paper form	171	57	228
% Complete paper	75%	25%	100%
Electronic form	228	0	228
% Complete electronic	100%	0%	100%

mandatory, therefore, rendering all forms complete. Using the Chi-Square test, we found an overall significant association between the type of record (electronic vs. paper) and the completion of the forms (χ^2 (1) = 273.600, $P \leq 0.001$), showing that electronic forms were more complete significantly.

For clarity of the data content, and to assess data quality, we categorized the variable into three sections: understandable, readable, and unclear. If there is no missing content in any of the fields in the form, we categorized the form as understandable. If there were two fields with some missing content within the form, we categorized the form as readable. If there were three or more fields with some missing content we categorized the form as unclear. As shown in Table 3, we found that the total of understandable paper-based laboratory forms was 11.4%, the total of readable forms was 33.8% and the total of unclear forms was 54.8%. For electronic based forms; there were no unclear electronic-based laboratory forms. However, there was a total of 21.1% of the forms that were understandable and a total of 78.9% that were readable. By running the chi-square to measure the association between variables, the result shows a significant association between type of record and clarity χ^2 (2) = 355.676, $P \leq 0.001$, showing that electronic forms were more clear and of higher quality significantly.

Discussion

The study revealed that that paper-based laboratory forms are less clear, less understandable and less complete than electronic-based laboratory forms. Although this finding is intuitive and similar to other findings within the field, this finding is new for Saudi Arabia. The first line of communication between the patients and the clinician is the laboratory form. Effective design and proper completion of laboratory request forms is essential to get a better performance from all laboratory tests and benefit diagnostics. We found many missing fields, and more frequently incomplete fields, when paper-based forms were used while switching to electronic-based forms would greatly improve the quality of care, efficiency, and productivity. Moreover, there are several advantages in using electronic-based system including but not limited to the following: (1) Enhancing the clarity of clinical diagnosis; (2) Improving access to patient tests ubiquitously; (3) Reducing duplication; (4) Improving clinical decision support, especially with patients who suffer from allergies.

From the patient's perspective, using electronic laboratory forms has several benefits. Due to the higher rate of data completeness the systems could be linked to improved diagnosis, which can be attributed to the complete filling of the laboratory forms within an electronic environment [1].

Table 3 Relation of record type to clarity filed.

Type of record		Clarity filed			
		Understandable	Readable	Unclear	Total
Paper	Count	26	77	125	228
	Percent	11.4%	33.8%	54.8%	100%
Electronic	Count	48	180	0	228
	Percent	21.1%	78.9%	0%	100%

When the diagnosis is reliable, the treatment of the patients becomes easier since the system can give predictions of what the ailments could be and the best treatment associated with the diagnosis data attained. Errors associated with manual data handling are eliminated when EHRs have been put in place in the diagnosis process. Studies show that many of the errors are a result of the different professionals involved before the final result can be achieved. When an error occurs in the initial stages of the data analysis, it is transferred to final stage affecting the outcomes but with the EHR all the task is done by a single tool and results released. As compared to the manual system, the EHR data processing is more efficient. When the process is efficient, then the patients are treated faster and this means the process of decision making is made by doctors faster [3].

On the other hand the doctors use the EHR to quickly link data transfer from one department to another within the healthcare facilities and outside. The data transfer is done electronically which saves the space and time used when data is on transit. The faster data analysis and diagnosis enables doctors to serve many patients within a limited time interval leading to increasing productivity of a given healthcare facility. Due to the automated aspects of EHR, the errors avoided can improve medical practices workflow. Electronic-based forms in laboratories allow easier and more coordinated care in comparison to paper-based forms. The coordinated functionalities of the systems are a result of implementing the integration of artificial intelligence and algorithms leading to a more comprehensive decision-making systems for quality healthcare services. The spaces used in file storage can be utilized for other functions in the facilities since the EHR systems use minimal space. One study discusses that confidentiality and completeness of the data is highly catered to since damage due minor human factors such as dirt does not affect hospital records while in electronic form [12].

Study limitations

Most of the paper-based forms used in the laboratory area focused on information filled in by clinicians so it was difficult to check for any alteration or if the exact test was requested for the patient by reviewing all their medical records since there is no laboratory authorization to do this. The shortage of published research on the topic; especially on the comparison between laboratory paper-based forms and electronic forms is another limitation. From an economic perspective, there is a financial impact to using paper-based forms that could not be evaluated during this study. Further studies may provide a more exact measurement of potential costs. Another important limitation was the MERS-Coronovirus Outbreak, most students who collected data from KAMC-RD faced the hospital being temporarily closed, this caused a major delay to collect both paper and electronic-based forms.

Recommendations

We recommend that the outpatient laboratory unit at KAMC implement the electronic-based laboratory system. With the implementation of the best care system across the hospital, the outpatient laboratory unit should start to work with the best care team and implement the system within the outpatient laboratory unit. Delaying the implementation may increase medical error rates and potentially cause unwanted harm to patients.

Conclusion

The study shows that paper-based forms are less understandable, less complete, and less readable than electronic-based forms. Important information required on the requisition forms was incomplete or missing. This could lead to low quality reports, misdiagnosis of test outcomes that may have harmful effects on patient administration, and might build the potential for future mistakes. Conversely, the provision of all information in an accessible clear form leads to the strengthening of health care which is a benefit passed on the patient. Some of the benefits felt in the health care affect doctors and include faster service deliveries, completeness in the health data, increased number of patients treated per day, and faster transfer of records from one departments to another. The most crucial benefit is the increase in accurate and fast generation of diagnosis reports which enhance treatment and managerial decisions. Incomplete information on laboratory requisition forms can lead to mismanagement and misdiagnosis of patients.

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Competing interests

None declared.

Ethical approval

Ethical approval was granted by King Abdullah International Medical Research Center.

Acknowledgment

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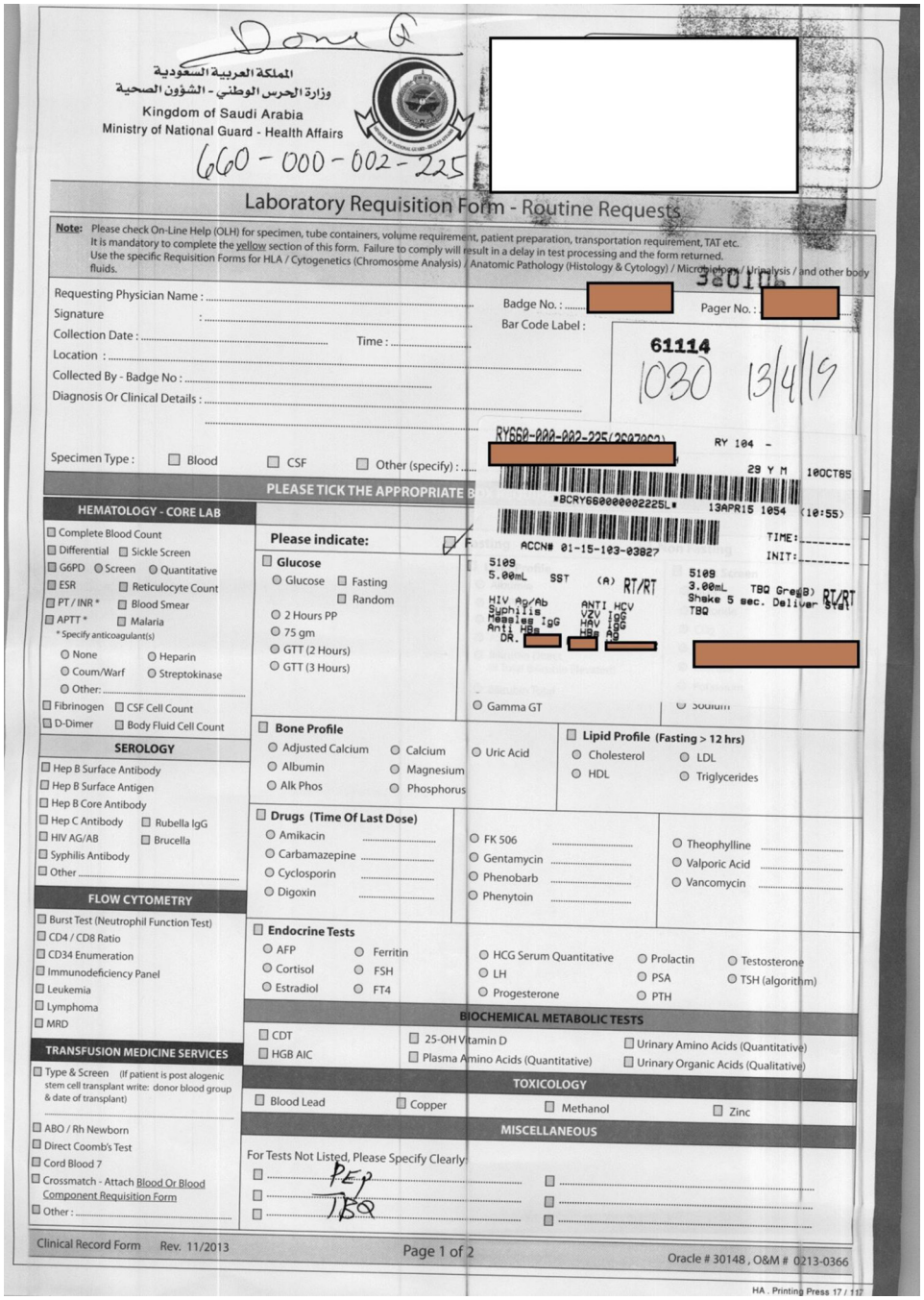
Appendix A.



المملكة العربية السعودية
وزارة الحرس الوطني - الشؤون الصحية
Kingdom of Saudi Arabia
Ministry of National Guard - Health Affairs

660 - 000 - 002 - 225

Laboratory Requisition Form - Routine Requests

Note: Please check On-Line Help (OLH) for specimen, tube containers, volume requirement, patient preparation, transportation requirement, TAT etc. It is mandatory to complete the yellow section of this form. Failure to comply will result in a delay in test processing and the form returned. Use the specific Requisition Forms for HLA / Cytogenetics (Chromosome Analysis) / Anatomic Pathology (Histology & Cytology) / Microbiology / Urinalysis / and other body fluids.

Requesting Physician Name : ..... Badge No. : [redacted] Pager No. : [redacted]
Signature : ..... Bar Code Label :
Collection Date : ..... Time : .....
Location : .....
Collected By - Badge No : .....
Diagnosis Or Clinical Details : .....

61114
1030 13/4/15

Specimen Type : ☐ Blood ☐ CSF ☐ Other (specify) : .....

PLEASE TICK THE APPROPRIATE B

HEMATOLOGY - CORE LAB
☐ Complete Blood Count
☐ Differential ☐ Sickle Screen
☐ G6PD ○ Screen ○ Quantitative
☐ ESR ☐ Reticulocyte Count
☐ PT / INR * ☐ Blood Smear
☐ APTT * ☐ Malaria
* Specify anticoagulant(s)
○ None ○ Heparin
○ Coum/Warf ○ Streptokinase
○ Other: .....
☐ Fibrinogen ☐ CSF Cell Count
☐ D-Dimer ☐ Body Fluid Cell Count

SEROLOGY
☐ Hep B Surface Antibody
☐ Hep B Surface Antigen
☐ Hep B Core Antibody
☐ Hep C Antibody ☐ Rubella IgG
☐ HIV AG/AB ☐ Brucella
☐ Syphilis Antibody
☐ Other .....

FLOW CYTOMETRY
☐ Burst Test (Neutrophil Function Test)
☐ CD4 / CD8 Ratio
☐ CD34 Enumeration
☐ Immunodeficiency Panel
☐ Leukemia
☐ Lymphoma
☐ MRD

TRANSFUSION MEDICINE SERVICES
☐ Type & Screen (If patient is post alogenic stem cell transplant write: donor blood group & date of transplant)
.....
☐ ABO / Rh Newborn
☐ Direct Coomb's Test
☐ Cord Blood 7
☐ Crossmatch - Attach Blood Or Blood Component Requisition Form
☐ Other : .....

Please indicate:

☐ Glucose
○ Glucose ☐ Fasting ☐ Random
○ 2 Hours PP
○ 75 gm
○ GTT (2 Hours)
○ GTT (3 Hours)

☐ Bone Profile
○ Adjusted Calcium ○ Calcium ○ Uric Acid
○ Albumin ○ Magnesium
○ Alk Phos ○ Phosphorus

☐ Drugs (Time Of Last Dose)
○ Amikacin .....
○ Carbamazepine .....
○ Cyclosporin .....
○ Digoxin .....
○ FK 506 .....
○ Gentamycin .....
○ Phenobarb .....
○ Phenytoin .....
○ Theophylline .....
○ Valporic Acid .....
○ Vancomycin .....

☐ Endocrine Tests
○ AFP ○ Ferritin
○ Cortisol ○ FSH
○ Estradiol ○ FT4
○ HCG Serum Quantitative ○ Prolactin ○ Testosterone
○ LH ○ PSA ○ TSH (algorithm)
○ Progesterone ○ PTH

BIOCHEMICAL METABOLIC TESTS
☐ CDT
☐ HGB AIC
☐ 25-OH Vitamin D
☐ Plasma Amino Acids (Quantitative)
☐ Urinary Amino Acids (Quantitative)
☐ Urinary Organic Acids (Qualitative)

TOXICOLOGY
☐ Blood Lead ☐ Copper ☐ Methanol ☐ Zinc

MISCELLANEOUS
For Tests Not Listed, Please Specify Clearly
☐ PEP ☐
☐ TSH ☐
☐ ☐

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