

Assessment of laboratory test requests from three hospital emergency departments

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ABSTRACT

Background: Laboratory requests can be justified and trimmed to what patients necessarily need. Reducing unnecessary laboratory requests can improve patient safety and both patient and provider satisfaction.

Methods: In this study, the current status of laboratory requests was assessed in emergency departments of three multidisciplinary university hospitals based on ten most expensive and most requested laboratory tests and categorised by the ordering physicians and patients' chief complaints in a 6-month period. These hospitals had annual visits to the emergency departments of between 20,000 – 72,000 patients.

Results: The most requested tests were as follows: complete blood count, biochemistry profile including sodium, potassium, urea, and creatinine. Moreover, the cumulating most expensive tests were coagulation profile, cardiac troponin, C-reactive protein, erythrocyte sedimentation rate, liver enzymes, alkaline phosphatase, and blood gases corresponding to the frequency of requests in the emergency department. Among the services, other than emergency medicine, requesting laboratory work in the emergency departments, internal medicine, neurology and surgery services had requested more laboratory tests comprising 44.0, 24.4, and 20.8 % of all specialties respectively. Moreover, the most frequent laboratory requests were from patients complaining of abdominal pain, chest pain, and penetrating or blunt traumatic injuries.

Conclusions: It should be considered to rationally request the most frequent laboratory tests as many of them can be canceled by physicians and do not change the diagnosis, treatment, prognosis, and disposition in the emergency department.

Key Words: diagnostic tests, routine, laboratories, emergency department.

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INTRODUCTION

Laboratory investigations are beneficial tools for screening, diagnosis or treatment monitoring, or assessing the complications of medications (1). Various approaches exist to request laboratory tests. According to Zhi et al., ordering tests with a clear indication referred to as restrictive criteria, while no contraindication is sufficient to order tests based on permissive criteria (1). Furthermore, objective criteria are investigator-independent while subjective criteria depend on expert review (1). Inappropriate testing can also be categorised into overutilisation including initial and repeated tests, and underutilisation, which is probably understudied (1). Overutilisation is thought to be more common, resulting from defensive medicine policies, the health system culture, unknown laboratory costs, and fear of receiving corrective feedback from the attending physicians during residency (2,3).

We aimed to assess the status of laboratory requests in three university hospital emergency departments categorised by patients complaints and the ordering physicians. The definite status of testing should be directed to optimise request protocols, improve patient safety, satisfaction of services providers, and decrease adverse events.

METHODS

The protocol of study has been reviewed and approved by the University of Medical Sciences Institutional Review Board and the ethical committee. It was in accordance with the ethical standards of the 1964 Helsinki declaration and its later ethical standards. Informed consent was obtained from the study participants.

In this cross-sectional study, we evaluated the topmost requested and most expensive laboratory requests during a fixed 6-month period in three university hospitals in the first 24 hours of patient entry to the emergency department in order to assess the present status of laboratory requests. These tests

were ranked based on the cumulating most expensive tests corresponding to the frequency of requests in the emergency department.

The three hospitals were dedicated to a university with a similar educational system and mainly similar undergraduate and postgraduate circulating physicians among their rotations. They are multidisciplinary referral centres with annual visits to the emergency department of between 20,000 – 72,000 patients. Hospitals A and B are respectively known as referral healthcare centres for infectious diseases and internal medicine subspecialty services (haematology, rheumatology, gastroenterology, and endocrine diseases) while hospital C is mainly referred as a trauma and urology centre, although all of them are staffed by 24/7 board-certified emergency medicine specialists and various medical residents visiting a variety of patients' problems and diseases. Patient flow protocols are different among the hospitals, especially for patient output from the emergency department to admission wards. Additionally, laboratory tests were limited in hospital C to only emergency requests.

Subgroup analysis was performed to categorise chief complaints and the physicians who requested these laboratory tests. To export the right output from the Hospital Informatics System of the three hospitals, we had coordinated with the engineers of information technology in the hospitals and held several meetings to reach the desirable results.

Data was exported to SPSS, version 23.0 for analysis. Estimates were reported with the precision of 95% confidence intervals (95% CIs), significance <0.05 and type II error <0.2. We used descriptive statistics and independent sample t-test to analyse continuous variables and χ^2 test for categorical variables. In case of non-parametric distribution, Mann-Whitneytest and Kruskal–Wallis analysis of variance were considered. Quantitative data were reported as mean and standard deviation, and qualitative ones were presented by number and percentage.

RESULTS

Data was analysed and presented in detail for the three university hospitals. Tables 1 and 2 depict the top ten most requested and most expensive laboratory tests, respectively. The common chief complaints relating to the laboratory data are presented in Table 3.

The laboratory expense per each patient was US\$ 9.6 for a total of 37,123 patients from hospital A. Hospital B acquired 163,064 laboratory data requests for 13,334 patients and the costs of laboratory tests per patient was US\$ 7.35. Interestingly, expenses were much lower per patient at US\$ 0.19 in hospital C.

Regarding the physicians requesting laboratory tests, the information from hospital A was not based on the ordering physician in the HIS system in a way that laboratory requests were assigned to the attending physician of anatomic clinical pathology service. However, the information of the treating physicians was obtained from the two other hospitals. In total, 57.0% were requested by the emergency medicine service in hospital B, followed by internal medicine 34.25 %, cardiology 3.29 %, surgery 1.27%, and neurology 1.07 % services. In hospital C, 98.1% of laboratory tests were ordered by emergency physicians. Among other treating services, internal medicine, neurology and surgery had requested more laboratory tests with 44.0, 24.4 and 20.8 % of the other services, respectively.

Table 1. Most requested laboratory tests in three university hospitals emergency departments.

Most requested laboratory tests									
	Hospital A			Hospital B			Hospital C		
	N=9,631,168	N	% †	N=163,064	N	%	N=28,761	N	%
1	CBC	17,359	15.3	CBC	17,358	10.6	CBC	2,395	8.3
2	Creatinine	14,781	13.1	Sodium	11,379	6.9	Creatinine	2,269	7.9
3	Potassium	14,767	13.0	Potassium	11,147	6.8	Urea	2,259	7.8
4	Sodium	14,732	13.0	Creatinine	10,051	6.1	Potassium	2,197	7.6
5	Urea	14,718	13.0	BUN	10,010	6.1	Sodium	2,181	7.6
6	PT/PTT/INR	12,626	11.1	VBG	9,263	5.6	Blood Glucose	1,980	6.9
7	Alkaline phosphatase	6,381	5.6	PTT	6,669	4.1	Troponin-I	1,122	3.9
8	SGOT, SGPT	6,382	5.6	PT	6,597	4.0	Calcium	1,017	3.5
9	Bilirubin [*]	5,990	5.3	UA	5,400	3.3	ABG/VBG	1,001	3.5
10	Calcium	5,394	4.8	Blood Glucose	3,442	2.1	UA	1,001	3.5
	Total	113,130	100		91,316	55.6		17,422	60.5

N: number. CBC: complete blood count. PT/PTT/INR: prothrombin time/partial thromboplastin time/ international normalisation ratio. SGOT/SGPT: serum glutamic oxaloacetic transaminase/serum glutamic pyruvic transaminase. BUN: blood urea nitrogen. VBG: venous blood gases/ABG: arterial blood gases. UA: urine analysis. ^{*}: total and direct.

† The percent of laboratory data of the first hospital represents the percentage out of the total number of top ten laboratory tests to avoid reporting near zero percent because of the overcrowded nature and numerous total laboratory requests in six months of the centre.

Table 2. The most expensive laboratory tests in three university hospitals emergency departments.

Most expensive laboratory tests									
No	Hospital A			Hospital B			Hospital C		
		N	% †		N	% of Total		N	% of Total
1	PT/PTT/INR	12,624	13.1	Potassium	11,147	6.8	Troponin-I	1,122	3.9
2	Alkaline phosphatase	6,382	6.6	VBG	9,263	5.6	CRP	685	2.4
3	SGOT, SGPT	6,381	6.6	SGOT	3,483	2.1	ESR	579	2.0
4	CRP	6,334	6.6	SGPT	3,453	2.1	PT/PTT/INR	541	1.9
5	Bilirubin [*]	5,990	6.2	Alkaline phosphatase	3,418	2.1	Amylase	295	1.0
6	Calcium	5,394		Troponin-I	3,101	1.9	CPK	145	0.5
7	CBC	3,567	5.6	Calcium	2,853	1.7	D-Dimer	119	0.4
8	Lipase	1,031	1.1	Bilirubin [*]	2,536	1.5	CK-MB	73	0.2
9	Serum Iron	599	0.6	D-dimer	229	0.1	Urine Toxicology	42	0.1
10	CK-MB	349	0.4	CK-MB	175	0.1	CSF	41	0.1
	Total	48,651	100		39,658	24.3		3,642	12.6

N: number. CBC: complete blood count. PT/PTT/INR: prothrombin time/partial thromboplastin time/ international normalisation ratio. SGOT/SGPT: serum glutamic oxaloacetic transaminase/serum glutamic pyruvic transaminase. BUN: blood urea nitrogen. VBG: venous blood gases/ABG: arterial blood gases. UA: urine analysis. ^{*}: total and direct.

†The percent of laboratory data of the first hospital represents the percentage out of the total number of top ten laboratory tests to avoid reporting near zero percent because of the overcrowded nature and numerous total laboratory requests in six months of the centre.

Table 3. Most requested laboratory tests categorized by chief complaints of patients.

Most requested laboratory tests categorized by chief complaints									
No	Hospital A			Hospital B			Hospital C		
	Complaints	N	%	Complaints	N	%	Complaints	N	% †
1	Abdominal pain	3,049	3.2	Abdominal pain	1638	13.2	Chest pain	37	23.7
2	Laceration	2,528	2.6	Multisystem trauma	1285	10.3	Urinary retention	25	16.0
3	Limb trauma	2,365	2.5	Dyspnea	805	6.5	↓ LOC	23	14.7
4	Generalized weakness	1,728	1.8	Chest pain	551	4.4	Stroke	14	9.0
5	Dyspnea	1,481	1.5	Limb pain	448	3.6	Abdominal pain	13	8.3
6	Chest pain	1,296	1.3	Stroke	434	3.5	Weakness	13	8.3
7	Multisystem trauma	1,262	1.3	Abnormal complete blood count	417	3.3	Headache	13	8.3
8	Suspected systemic infection	1,236	1.3	Gastrointestinal bleeding	406	3.3	Seizure	9	5.8
9	Flank pain	950	1.0	Flank pain	365	2.9	Renal colic	6	3.8
10	Headache	719	0.7	Vertigo	337	2.7	Multiple trauma	3	1.9
	Total	96,368	17.2		5638	53.7		156	100

N: Number of documented complaints. LOC: decreased level of consciousness.

† The percent of laboratory data of the third hospital represents the percentage out of the total number of top ten chief complaints to avoid reporting near zero percent because of the significant missing data of chief complaint.

DISCUSSION

In order to determine the status of laboratory requests in the emergency department the information of three university hospitals emergency departments was assessed. The top five most common requested tests in all three hospitals were complete blood count, and biochemistry profile including creatinine, potassium, sodium, and blood urea nitrogen, but the following most requested laboratory sequence was varied. For instance, prothrombin time and partial thromboplastin time were mostly requested in two of the hospitals. It can be caused by differences between the typical patient populations presented to these referral hospitals. On the other hand, it can be due to the limitations applied for the laboratory requests of hospital C in the emergency department. In this context it is clear that further stay in the emergency room necessitates more laboratory requests (1). Furthermore, the requested number of laboratory tests is affected by some emergency department protocols, thus limiting the request of non-urgent tests that occurred in hospital C, canceling elective laboratory tests in the emergency department. This strategy not only limits the burden of unnecessary laboratory requests by postponing them to outpatient visits, but also cause swifter flow of patients in hospital C, urging treating services other than the emergency department to mobilise their patients to the wards to perform further necessary but non-urgent tests during ward admission. Some researchers have implemented short-term educational interventions aimed at reducing the number of inappropriate laboratory tests in a university hospital. They restricted available emergency laboratory tests and the frequency of repeated orders via an institutional protocol and showed a reduction of 19% in laboratory tests (95% CI: 18.8–19.2% in the year after the intervention (4). This effect on haematology test reduction was 7.6% ($P = 0.009$). Another study showed a decrease of 37% in requested laboratory tests after the institution of guidelines ($p < 0.001$ in a surgical intensive care unit (5). The most common requested tests were related to the patients with abdominal pain, chest pain, lacerations, multiple

trauma, and urinary retention in three hospitals which were ordered by emergency medicine, internal medicine, neurology, and surgery services, respectively. It is important to note that some complaints such as minor lacerations and urinary retention may not need any laboratory tests and institutional protocols are needed to determine the minimum necessary laboratory tests.

Our study showed that the most expensive requested tests were prothrombin time, partial thromboplastin time, international normalisation ratio, potassium, troponin, alkaline phosphatase, venous blood gases, and C-reactive protein in the three hospitals. Some of the most common requested tests are not expensive but this was due to the high volume of requests, which may not be necessary. In general, unnecessary tests are not only ineffective in patients' diagnosis and management, but also cause several shortcomings, such as increased patient's length of stay and results in increasing patient and personnel dissatisfaction due to financial issues. In this context, several studies have been designed to decrease unnecessary requested tests. For instance, Oliveira et al., showed that the most requested tests were complete blood count, sodium, and potassium, of which 41% of tests were considered unnecessary in this interventional assessment (4).

Nearly all interventions, such as education or feedback, lead to a reduction in laboratory requests according to a narrative review (6). Some authors assessed requested tests before and after educating internal medicine residents and showed that blood tests and the LOS decreased by 50% and 21%, respectively (7). Similar results were found in another studies by educating residents, limiting common laboratory or repeated test requests (8-10), and few beneficial protocols exist (11).

In addition, we confronted different patient outflow protocols from the emergency wards in a way that hospitals A and B, with more complicated infectious and internal medicine complaints, may have more length of stay in their emergency departments and therefore the rate and type of laboratory requests exceed expectations. However, hospital C, with more traumatic patient

visits, have a quicker turnaround rate in the emergency department with hospital bed management of emergency medicine attending physicians. Furthermore, there is an interesting alignment with the expensive laboratory tests requested by hospital C (Table 2) and the “most common complaints” in Table 3 that may be due to the less common complicated internal medicine patients referring to this hospital. Some authors considered that inappropriate laboratory requests were common in internal medicine due to the lack of awareness and knowledge and feelings of insecurity were causes of excessive requests among internal medicine residents (12). Finally, some authors discuss approaches to decrease inappropriate laboratory test utilisation and their financial effects in the University of Colorado including reimbursement rate reduction, decreasing the utilisation of unnecessary tests, test utilisation management by laboratory staff and installation of advanced information technology systems. The authors emphasise that combination of these approaches will be helpful (13).

A limitation of our study was that the hospital informatics system systems of the three hospitals were not unified; thus, the documentation pattern was different among them. Furthermore, some missing data existed, especially in the determination of patients' clinical complaints.

In conclusion, common laboratory requests were differently managed in the three hospitals. Applying limitations to the emergency department laboratory requests and relying on necessary tests can improve patient turnaround and overcrowding. Patient flow and hospital bed management by emergency physicians seem to be influential and are positive factors on optimal laboratory requests. Our study data is beneficial to recognise the type, physician, and services responsible for unnecessary laboratory test requests.

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REFERENCES

1. Zhi M Ding EL, Theisen-Toupal J, et al. The landscape of inappropriate laboratory testing: a 15-year meta-analysis. *PLoS ONE* 2013; 8(11): e78962.
2. Sedrak M, Patel, MS, Ziembra, JB, et al. Residents' self-report on why they order perceived unnecessary inpatient laboratory tests. *J Hosp Med* 2016; 11(12): 869-872.
3. Koch C, Roberts K, Petrucci C, Morgan DJ. The frequency of unnecessary testing in hospitalized patients. *Am J Med* 2018; 131(5): 500-503.
4. Oliveira AM, Oliveira MV, Souza CL. Prevalence of unnecessary laboratory tests and related avoidable costs in intensive care unit. *J Brasil Pathol Med Lab* 2014; 50(6): 410-416.
5. Kumwilaisak K, Noto A, Schmidt UH, et al. Effect of laboratory testing guidelines on the utilization of tests and order entries in a surgical intensive care unit. *Crit Care Med* 2008; 36(11): 2993-2999.
6. Bindraban RS, ten Berg MJ, Naaktgeboren CA, et al. Reducing test utilization in hospital settings: a narrative review. *Ann Lab Med* 2018; 38(5): 402-412.
7. Faisal A, Andres K, Rind JAK, et al. Reducing the number of unnecessary routine laboratory tests through education of internal medicine residents. *Postgrad Med J* 2018;94(1118):716-719
8. Arole O, Rajan J, Khan S, et al. Decreasing unnecessary daily labs by choosing wisely. *Patient Saf Qual Improv* 2017; 5(4): 630-633.
9. May TA, Clancy M, Critchfield J, et al. Reducing unnecessary inpatient laboratory testing in a teaching hospital. *Am J Clin Pathol* 2006; 126(2): 200-206.
10. Khalifa M, Khalid P. Reducing unnecessary laboratory testing using health informatics applications: a case study on a tertiary care hospital. *Proc Computer Sci* 2014; 37: 253-260.
11. Mehari S, Havill J. Written guidelines for laboratory testing in intensive care-still effective after 3 years. *Crit Care Resusc* 2001; 3(3): 158-162.
12. Vrijssen BEL, Naaktgeboren CA, Vos LM, et al. Inappropriate laboratory testing in internal medicine inpatients: Prevalence, causes and interventions. *Ann Med Surg (Lond)* 2020;51:48-53.
13. Wilson ML. Decreasing inappropriate laboratory test utilization: controlling costs and improving quality of care. *Am J Clin Pathol* 2015; 143(5): 614-616.

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