SHORT RESEARCH ARTICLE

Paging Doctor Google! Heuristics vs. technology [version 1; peer review: 1 approved, 1 approved with reservations]

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Abstract

The most dramatic development in medical decision-making technology has been the advent of the Internet. This has had an impact not only on clinicians, but has also become an important resource for patients who often approach their doctors with medical information they have obtained from the Internet. Increasingly, medical students, residents and attending physicians have been using the Internet as a tool for diagnosing and treating disease. Internet-based resources that are available take various forms, including informational websites, online journals and textbooks, and social media. Search engines such as Google have been increasingly used to help in making diagnoses of disease entities. Do these search methods fare better than experienced heuristic methods? In a small study, we examined the comparative role of heuristics versus the 'Google' mode of thinking. Internal medicine residents were asked to “google” key words to come up with a diagnosis. Their results were compared to experienced nephrology faculty and fellows in training using heuristics and no additional help of internet. Overall, with the aid of Google, the novices (internal medicine residents) correctly diagnosed renal diseases less often than the experts (the attendings) but with the same frequency as the intermediates (nephrology fellows). However, in a subgroup analysis of both common diseases and rare diseases, the novices correctly diagnosed renal diseases less often than the experts but more often than the intermediates in each analysis. The novices correctly diagnosed renal diseases with the same frequency as nephrology fellows in training.

Keywords

google, Dr.Google, diagnostic skills, residency, nephrology

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Any reports and responses or comments on the article can be found at the end of the article.

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Introduction

In medical problem solving and decision-making, experts often use heuristics, or methods of problem solving for which no formula exists, but are instead based on informal methods or experience[1]. Heuristics help generate accurate decisions in an economical manner for both time and cost. In a sense, expert strategies are immensely adaptive[1]. While invaluable in helping the experienced clinician arrive at a diagnosis faster, the use of heuristics is associated with biases inherent in efficient decision making and, therefore, can lead to specific patterns of error[2]. The use of technology employs an algorithmic, rather than a heuristic, approach to medical problem solving and at speeds much greater than human capacity. Various technologies have been experimented with in medicine for years. Past efforts have included computer programs specifically designed to help clinicians make medical decisions and diagnose conditions more efficiently and accurately[1,3]. Electronic medical records and information technology have improved access to and ease of use of patient data. Technology does not merely facilitate or augment decision-making, but it reorganizes decision-making practices[1].

Enter "Dr. Google"

The most dramatic development in medical decision technology has been the advent of the Internet. Use of social media tools such as Facebook and Twitter allow for sharing of information and getting information at a much faster rate than previously thought. Search engines have slowly emerged as useful tools to get data regarding medical knowledge. Clinicians can utilize search engines to help them with decision-making. Search engines, the most popular of which is Google[3], allow for the algorithmic surveying of all available information in an attempt to provide the most meaningful and useful information to the end user. It is plausible that the use of search engines could substantially aid the clinician, especially when dealing with diagnostic or therapeutic challenges involving great complexity and multiple variables, but the effectiveness of search engines as an aid to the clinician is incompletely defined, as suggested by a recent study by Krause *et al.*[4].

As technology infiltrates everyday medicine, the debate about the appropriate role for information technology within medicine has intensified[5,6]. Early on, concern was raised regarding the utility of search engines to direct patients and clinicians to relevant sources[7]. More recently, there is mounting anecdotal evidence of miraculous or fantastic accounts of patients and physicians-in-training "googling" the answer to a medical question that had experts stumped[8]. There have been several small studies looking at the ability of doctors at various levels of training and experience to correctly diagnose a disease using Google based on case presentations from the *New England Journal of Medicine (NEJM)*. Falagas *et al*. did a head-to-head comparison of three learners (two medical students and one "trainee doctor") in which the learners first provided their diagnoses to *NEJM* cases without help, and then repeated the exercise with the help of Google and Pubmed[9]. While the findings did not reach statistical significance, the study suggested that use of Google and Pubmed may be helpful in generating a differential diagnosis[9]. Tang and Ng took 26 cases, also from the case records series in the New England Journal of Medicine, and selected 3–5 search terms for each case and entered them into Google[10]. Using this approach, the Google search provided the correct diagnosis in 58% of the cases[10]. The conclusions of the studies were essentially the same: Google (and probably other search engines and algorithmic technologies) appears to be a viable clinical tool to aid in physician diagnosis and learning.

Comparison

Does "googling" a diagnosis replace an experienced physician's clinical acumen? "Googling" a clinical question may be especially useful in the case of rare or syndromic diseases, but may be less likely to be useful in diagnosing more common diseases. To assess this possibility, we reviewed and analyzed the use of Google as a diagnostic tool in renal diseases and compared it to the experience of fellows and attending staff. A total of 21 members participated in the study (7 novices, 7 intermediate levels- fellows and 7 experts - attendings). We created 103 pairings of common and uncommon renal diseases with keywords related to the features of the disease using a standard renal textbook as a guide (Appendix 1). The diseases were then categorized as common or rare based upon the consensus of the investigators. This association was not indicated on the worksheets given to the participants. The order of the questions was then randomized and worksheets were made with approximately fifteen keyword pairings per page. Experts (nephrology attendings) and intermediates (nephrology fellows) were given the entire list of keywords (one page at a time) and asked to identify the associated diseases without any aid. Novices (first- and second-year internal medicine residents) were given approximately three pages at random and asked to use Google to identify the renal disease associated with the keywords. The novices were given standardized instructions requiring that they only use the first ten results (first page of results) returned from a Google search. They were then only permitted to use the first page of each of the ten results that appear on the first Google search page. A detailed instruction sheet is attached for reference (Appendix 2). The residents were instructed to use any or all of the keywords, as they saw fit, and they were allowed to try different iterations of the keywords if their original search did not yield a diagnosis they were satisfied with. The residents were supervised/proctored by one of the investigators; questions were limited to explanations of the rules. The percent of diagnoses correctly identified from the keywords was identified for each test-taking group, and the groups were compared with each other two at a time. The diseases were then categorized as common or rare based upon consensus of the investigators. Worksheets were created with keywords groupings for each disease listed and space provided for a study participant to record the suspected diagnosis. The association of common versus rare was not indicated on the worksheets given to the participants. The participants were asked to complete as many pages as they were willing to complete. All participating experts answered a total of 229 questions. All participating intermediates answered a total of 254 questions. All participating novices answered a total of 230 questions.

The percent of diagnoses correctly identified from the keywords was identified for each test-taking group and the groups were compared with each other two at a time. A t-test was calculated for each pairing; p-values were calculated using Microsoft Excel. A subgroup analysis was also conducted for common diseases and for rare diseases. Table 1 and Table 2 show examples of the common and rare diseases chosen, and the keywords and their associated diseases, respectively.

Table 1. Examples of common and rare diseases used in this study.

Common	Rare
Renal tubular acidosis type IV (hyporeninemic hypoaldosteronism)	Syndrome of apparent mineralocorticoid excess (AME)
Acute interstitial nephritis (AIN)	Tuberous sclerosis
Rhabdomyolysis	Pheochromocytoma
Hepatorenal syndrome	Ethylene glycol poisoning
Thin basement membrane disease	Churgh-Strauss syndrome

Table 2. Examples of the Keywords used and their associated diseases.

Keyword	Disease
Severe hypertension, Rapidly progressive acute renal failure, rapid skin thickening, high renin	Scleroderma renal crisis
Oliguric acute renal failure, glomerulonephritis, pulmonary hemorrhage, anti-GBM Ab+	Goodpasture's syndrome
Progressive glomerulonephritis, fever, fatigue, epistaxis, c-ANCA/PR3-ANCA+	Granulomatosis with polyangiitis
Fever, watery diarrhea, acute renal failure, anemia, thrombocytopenia	Hemolytic uremic syndrome (HUS)
Young woman, hypertension, renal artery stenosis on ultrasound	Fibromuscular dysplasia

Is "Dr. Google" better than experience?

Overall, with the aid of Google, the novices (internal medicine residents) correctly diagnosed renal diseases less often than the experts (nephrology attendings) (72.2% vs. 84.7%, $p<0.001$), but with the same frequency as the intermediates (nephrology fellows) (72.2% vs. 71.5%, $p=0.795$). In a subgroup analysis of common diseases, the novices correctly diagnosed renal diseases less often than the experts (76.6% vs. 90.5%, $p<0.001$) and intermediates (76.6% vs. 82.3%, $p=0.031$). However, in a subgroup analysis of rare diseases, the novices correctly diagnosed renal diseases less often than the experts (65.2% vs. 76.1%, $p=0.014$), but more often than the intermediates (65.2% vs. 56.2%, $p=0.029$). This study is unique, in that it directly compares heuristic and algorithmic problem solving, using the dominant technology of our time: the Internet via Google. It also addresses which types of problems are best solved using the heuristics of an experienced clinician and which problems benefit most from algorithmic problem solving with the aid of a search engine. Limitations of the short research include single center study, investigator bias and limited number of participants. While this question will require further study, our findings suggest that for uncommon clinical entities, the use of search engine technology may be able to increase the diagnostic performance of a novice to an intermediate level.

Would you use Google to help diagnose your patient?

Can the computer really out think the doctor in making a diagnosis? A recent editorial in *The New York Times*[11] begs this question as well and suggests that in rare diseases, and in many instances, a computer software program would have saved many lives. This might be true for rarely encountered conditions but perhaps not for common diseases. Rare diseases are often not diagnosed at the first encounter with a physician, and hence the term "rare". A computer-based query, as used in Google, might help diagnose a rare illness faster, but cannot substitute for the heuristic thinking process of a physician and the matching of patterns facilitated by a physician's experience. Hence, while search engines and diagnostic programs will likely continue to evolve as diagnostic tools, they can aid, but cannot replace the thought processes of the experienced clinician.

Author contributions

KDJ and PBS designed the idea. The concept and experiment were IRB exempt at NSLIJ Health System. KDJ and JM wrote the manuscript.

Competing interests

No relevant competing interests were disclosed.

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Reference Source

	Key Words	Disease
1	Young adults, proteinuria, hematuria, drusen in eye, decreased C3 and C4	
2	Altered Mental Status, lactic acidosis, other members of household with headache, mild confusion, nausea	
3	Severe Hypertension, Rapidly progressive Acute Renal Failure, rapid skin thickening, high renin	
4	Hypocalcemia, hypophosphatemia, s/p parathyroidectomy	
5	Proteinuria, hematuria, acute renal failure, history of Chronic Lymphocytic Leukemia, unusual deposits on kidney biopsy	
6	Slowly rising creatinine, hematuria, proteinuria, low C3	
7	Severe Hypertension, hypokalemia, metabolic alkalosis, low serum aldosterone	
8	Metabolic acidosis, urine pH > 5.5, positive urine anion gap	
9	Progressive Renal Failure, proteinuria, hypocomplementemia, high AST/ALT, cryoglobulinemia	
10	Back pain, Acute Renal Failure, hypercalcemia, anemia	
11	Fever, Cough, dysuria, microscopic hematuria, Acute Renal Failure, normal complement	
12	Oliguric Acute Renal Failure, glomerulonephritis, pulmonary hemorrhage, anti-GBM Ab+	
13	Acute Renal Failure, recent treatment for Acute Lymphoblastic Leukemia, hyperuricemia, hyperkalemia, hyperphosphatemia, metabolic acidosis	
14	Slowly progressive CKD, hyperuricemia, hypertension, works as a mechanic	
15	Hypernatremia, geriatric, no thirst, high urine osmolality, brain mass on CT	
16	Fever, lethargy, muscle pain, Acute Renal Failure, proteinuria, edema, aplastic anemia	
17	Abrupt onset of Hypertension, recurrent flash pulmonary edema, U/Sà asymmetric kidney size	
18	Hyponatremia, euvolemia, low plasma osmolality, high urine osmolality	
19	CKD, increased PTH, decreased 1,25-OH Vit D, hyperphosphatemia	
20	Acute Renal Failure, HIV, nephrogenic diabetes incipidus, hypomagnesemia	
21	Hypernatremia, low urinary osmolality, urine osmolality increases with DDAVP	
22	Metabolic acidosis, high anion gap, hyperglycemia	
23	Hypercalcemia, low PTH, lung nodule	
24	Acidosis, aminoaciduria, glycosuria, hypouricemia, hypophosphatemia	
25	Acute Renal Failure, Hematuria, Hypertension, pulmonary edema, sore throat 2 weeks ago	
26	African American, Acute Renal Failure, proteinuria, edema, Hypertension, obese	
27	Hypercalcemia, recurrent kidney stones, hyperparathyroidism, recurrent hypoglycemia, pituitary adenoma	
28	Intoxicated, metabolic gap acidosis, urineàoxalate crystals, no ketones	
29	Hypercalcemia, hypercalciuria, bilateral pulmonary hilar adenopathy, heart block	

	Key Words	Disease
30	Hypotension, hyperkalemia, hypoglycemia, metabolic acidosis, hypercalcemia, hyponatremia	
31	Advanced CKD, ataxia, blurry vision, alopecia, takes multiple supplements from health food store	
32	Acute Renal Failure, asthma, eosiniophilia	
33	Hyponatremia, increased thirst, polyuria, low serum and urine osmolality	
34	ESRD, carpal tunnel syndrome, shoulder arthalgia, subchondral bone cysts on x-ray	
35	Renal Failure, proteinuria, new CHF, biopsy w/mesangial nodules, elevated free lambda light chain	
36	Intoxicated, anion gap metabolic acidosis, normal osmolar gap	
37	Acute Renal Failure, headaches, IgM spike on immunofixation, hepatosplenomegaly, amyloidosis on kidney biopsy	
38	Cerebellar and retinal hemangioblastoma, pancreatic cyst, renal cysts	
39	Metabolic acidosis, bicarbinaturia with bicarbonate supplementation	
40	Bilateral flank pain, Hypertension, Family History Kidney Disease, RUQ U/S with multiple liver cysts	
41	Alcoholic pancreatitis s/p NPO for 8 days, hypophosphatemia, hypokalemia, hypomagnesemia	
42	Acute Renal Failure, nephrotic syndrome hypocomplementemia, high AST/ALT, biopsyà membranous glomerulopathy	
43	Fungemia, nonoliguric Acute Renal Failure, hypokalemia, hypomagnesemia, dilute urine	
44	Hypokalemia, metabolic alkalosis, mild hypotension, hypocalciuria, hypomagnesemia	
45	Hematuria, eosinophilia, urine microscopyà eggs	
46	Acute Renal Failure, urinary tract infection from Proteus mirabilis, hydronephrosis, staghorn calculi	
47	Hypertension, obesity, facial fat deposition, striae, high cortisol not suppressed with either high dose or low dose dexamethasone suppression test	
48	Acute Renal Failure, polyuria, gentamicin administration	
49	Hyperkalemia, hyponatremia, non AG metabolic acidosis, high urine and serum aldosterone, high plasma renin activity	
50	Fever, lethargy, hematuria, proteinuria, low platelets, anemia	
51	Female, recurrent urinary tract infections, flank pain, palpable unilateral renal mass	
52	Hyperkalemia, metabolic acidosis, low renin, low aldosterone	
53	Obesity s/p gastric bypass, nephrolithiasis, hypercalciuria	
54	Acute Renal Failure, rash, arthralgia, fever, eosinophilia, U/Aà RBC, WBC	
55	Pregnancy, hypertension, proteinuria, edema, elevated uric acid	
56	Hypertension, obesity, facial fat deposition, striae, high cortisol suppressed with high dose but not low dose dexamethasone suppression test	
57	Acute Renal Failure, African descent, Proteinuria, U/Sà Enlarged, ecogenic kidneys, biopsyà collapsing FSGS, normotensive, no edema	

	Key Words	Disease
58	Mild Hyponatremia, severe hyperglycemia	
59	Acute Renal Failure, Biopsyà thrombotic microangiopathy, recent treatment for pancreatic cancer	
60	Seizure, Acute Renal Failure, hypokalemia, hypomagnesemia	
61	Acute Renal Failure, proteinuria, edema, steroid responsive, biopsyà one glomerulus with swelling, vacuolation, and proliferation near proximal tubule	
62	ESRD on HD, hip fracture, hypercalcemia, low/normal iPTH	
63	Male, CKD, polyuria, polydypsia, Angiokeratomas, CHF	
64	Nephrolithiasis, obesity, diet high in animal protein, low urine pH	
65	Microhematuria, normal creatinine, family history of hematuria	
66	Male, hypophosphatemia, phosphaturia, normal serum 1,25-OH Vit D, calcium, PTH , high alkaline phosphatase, bow-legged	
67	Acute Renal Failure, hyponatremia, liver cirrhosis, ascites, low urinary sodium	
68	Edema, proteinuria, Acute Renal Failure, weight loss, anemia, occult blood positive, abdominal fullness	
69	Progressive glomerulonephritis, fever, fatigue, epistaxis, c-ANCA/PR3-ANCA +	
70	Progressive CKD, young age of onset, rentinitis pigmentosa, U/A à bland, no hematuria or proteinuria	
71	Interstitial nephritis, hypokalemia, distal RTA, dry eyes, dry mouth	
72	Hypocalcemia, hypomagnesemia, s/p thyroidectomy	
73	ESRD on HD, high iPTH, high calcium, high phosphorus	
74	Acute Renal Failure, recent treatment for Acute Lymphoblastic Leukemia, normokalemia, normal phosphate	
75	Hypertension, hypokalemia, metabolic alkalosis, low renin, low aldosterone	
76	Acute Renal Failure, Low platelets, anemia, high LDH, biopsyà thrombotic microangiopathy, recent treatment for metastatic colorectal cancer	
77	Nephrotic syndrome, diuretic use, flank pain, hematuria, elevated LDH, U/Sà unilateral enlarged kidney	
78	CKD, Flank pain, U/S shows bilateral cysts all <3 cm, no family history of kidney disease	
79	Resistant Hypertension, hypokalemia, high plasma aldosterone concentration to plasma renin activity (high PAC/PRA)	
80	Acute Renal Failure on CKD, CT scan one day ago	
81	SIADH, lethargy, constipation, cold intolerance	
82	Edema, sudden onset proteinuria, age 19	
83	Acute Renal Failure, BPH, U/Sà hydronephrosis	
84	Young woman, hypertension, renal artery stenosis on ultrasound	
85	Episodic hypertension with flushing, thyroid nodule, diarrhea	
86	Renal cysts, renal angiomyolipomas, hypertension, haratomatous tumors in multiple organ systems	

	Key Words	Disease
87	Episodic hypertension with headache, sweating, tachycardia, diabetes, hypercalcemia, orthostatic hypotension	
88	Renal Vein thrombosis, Acute Renal Failure, multiple spontaneous abortions	
89	African descent, mild proteinuria, slowly progressive CKD, MPGN	
90	Hypokalemia, metabolic alkalosis, normal urinary chloride, hypercalciuria	
91	Edema, proteinuria, Acute Renal Failure, cyclic fever, recent travel to Brazilian rainforests	
92	hematuria, proteinuria, joint inflammation, rash, ANA+, dsDNA+	
93	Hypercalcemia, hypophosphatemia, metabolic alkalosis, peptic ulcer disease (PUD)	
94	Male, smoker, Hypertension, s/p cardiac angiography, Acute Kidney Injury	
95	Hematuria, recurrent UTIs, multiple small stone nephrolithiasis, family history kidney disease, distal RTA	
96	CKD, hypercalcemia, bipolar disorder, no proteinuria	
97	Progressive glomerulonephritis, fevers, joint pain, p-ANCA/MPO-ANCA +	
98	Hypernatremia, low urinary osmolality, recent head injury, unresponsive to DDAVP	
99	History of bone marrow transplant, low platelets, high LDH, low haptoglobin, anemia, chronic renal failure, kidney biopsy showing thrombotic microangiopathy	
100	Fever, watery diarrhea, Acute Renal Failure, anemia, thrombocytopenia	
101	Male, microscopic hematuria, hearing loss	
102	EtOH withdrawal on Ativan gtt for several days with “banana bag,” with new onset anion gap metabolic acidosis	
103	Hyperglycemia, microalbuminuria, diffuse mesangial expansion	

Appendix 1: List of key words given to study participants. The first section is the blank keywords and the second is the answer key to the key words. (Section 1).

	Diagnosis	Key words
1	Dense Deposit Disease	Young adults, proteinuria, hematuria, drusen in eye, decreased C3 and C4
2	Carbon monoxide poisoning	Altered Mental Status, lactic acidosis, other members of household with headache, mild confusion, nausea
3	Scleroderma Renal Crisis	Severe Hypertension, rapidly progressive Acute Renal Failure, rapid skin thickening, high renin
4	Hungry Bone Syndrome	Hypocalcemia, hypophosphatemia, s/p parathyroidectomy
5	Immunotactoid glomerulonephritis	Proteinuria, hematuria, acute renal failure, history of chronic lymphocytic leukemia, unusual deposits on kidney biopsy
6	Membranoproliferative glomerulonephritis (MPGN) type 1	Slowly rising creatinine, hematuria, proteinuria, low C3
7	Liddle's Syndrome (pseudohyperaldosteronism)	Severe hypertension, hypokalemia, metabolic alkalosis, low serum aldosterone
8	Renal tubular acidosis type 1 (Distal RTA-Classic)	Metabolic acidosis, urine pH > 5.5, positive urine anion gap
9	Hep C virus-related glomerulopathy	Progressive renal failure, proteinuria, hypocomplementemia, high AST/ALT, cryoglobulinemia
10	Multiple myeloma	Back pain, acute renal failure, hypercalcemia, anemia
11	IgA Nephropathy	Fever, Cough, dysuria, microscopic hematuria, Acute Renal Failure, normal complement
12	Goodpasture's Syndrome	Oliguric Acute Renal Failure, glomerulonephritis, pulmonary hemorrhage, anti-GBM Ab+
13	Tumor lysis Syndrome	Acute renal failure, recent treatment for Acute Lymphoblastic Leukemia, hyperuricemia, hyperkalemia, hyperphosphatemia, metabolic acidosis
14	Lead Nephropathy	Slowly progressive CKD, hyperuricemia, hypertension, works as a mechanic
15	Adypsic Hypernatremia	Hypernatremia, geriatric, no thirst, high urine osmolality, brain mass on CT
16	Focal Segmental Glomerulosclerosis (FSGS) (collapsing variant) 2° parvovirus B19	Fever, lethargy, muscle pain, Acute Renal Failure, proteinuria, edema, aplastic anemia
17	Renovascular Hypertension/renal artery stenosis	Abrupt onset of Hypertension, recurrent flash pulmonary edema, U/Sà asymmetric kidney size
18	Syndrome of inappropriate antidiuretic hormone (SIADH)	Hyponatremia, euvolemia, low plasma osmolality, high urine osmolality
19	Secondary hyperparathyroidism	CKD, increased PTH, decreased 1,25-OH Vit D, hyperphosphatemia
20	Foscarnet Toxicity	Acute Renal Failure, HIV, nephrogenic diabetes incipidus, hypomagnesemia
21	Nephrogenic Diabetes insipidus	Hypernatremia, low urinary osmolality, urine osmolality increases with DDAVP
22	Diabetic Ketoacidosis	Metabolic acidosis, high anion gap, hyperglycemia
23	Humoral hypercalcemia of malignancy	Hypercalcemia, low PTH, lung nodule
24	Fanconi's Syndrome	Acidosis, aminoaciduria, glycosuria, hypouricemia, hypophosphatemia
25	Post-infectious GN (Post-strep GN)	Acute Renal Failure, Hematuria, Hypertension, pulmonary edema, sore throat 2 weeks ago

	Diagnosis	Key words
26	Focal Segmental Glomerulosclerosis (FSGS), primary	African, American, Acute Renal Failure, proteinuria, edema, Hypertension, obese
27	Multiple Endocrine Neoplasia type 1 (MEN I)	Hypercalcemia, recurrent kidney stones, hyperparathyroidism, recurrent hypoglycemia, pituitary adenoma
28	Ethylene glycol poisoning	Intoxicated, metabolic gap acidosis, urineàoxalate crystals, no ketones
29	Sarcoidosis	Hypercalcemia, hypercalciuria, bilateral pulmonary hilar adenopathy, heart block
30	Adrenal Insufficiency	Hypotension, hyperkalemia, hypoglycemia, metabolic acidosis, hypercalcemia, hyponatremia
31	Vitamin A intoxication (chronic)	Advanced CKD, ataxia, blurry vision, alopecia, takes multiple supplements from health food store
32	Churgh-Strauss syndrome	Acute Renal Failure, asthma, eosiniophilia
33	Psychogenic polydypsia	Hyponatremia, increased thirst, polyuria, low serum and urine osmolality
34	Osteoarticular Amyloidosis	ESRD, carpal tunnel syndrome, shoulder arthalgia, subchondral bone cysts on x-ray
35	Primary Amyloidosis (AL-type)	Renal Failure, proteinuria, new CHF, biopsy w/ mesangial nodules, elevated free lambda light chain
36	Isopropyl alcohol poisoning	Intoxicated, anion gap metabolic acidosis, normal osmolar gap
37	Waldenstrom's Macroglobulinemia	Acute Renal Failure, headaches, IgM spike on immunofixation, hepatosplenomegaly, amyloidosis on kidney biopsy
38	Von Hippel-Lindau syndrome	Cerebellar and retinal hemangioblastoma, pancreatic cyst, renal cysts
39	Renal tubular acidosis type II (Proximal RTA)	Metabolic acidosis, bicarbinaturia with bicarbonate supplementation
40	Autosomal Dominant Polycystic Kidney Disease (ADPKD)	Bilateral flank pain, Hypertension, Family History Kidney Disease, RUQ U/S with multiple liver cysts
41	Refeeding Syndrome	Alcoholic pancreatitis s/p NPO for 8 days, hypophosphatemia, hypokalemia, hypomagnesemia
42	Hep B virus-related glomerulopathy	Acute Renal Failure, nephrotic syndrome hypocomplementemia, high AST/ALT, biopsyà membranous glomerulopathy
43	Amphotericin B toxicity	Fungemia, nonoliguric Acute Renal Failure, hypokalemia, hypomagnesemia, dilute urine
44	Gitelman's Syndrome	Hypokalemia, metabolic alkalosis, mild hypotension, hypocalciuria, hypomagnesemia
45	Schistosomiasis	Hematuria, eosinophilia, urine microscopyà eggs
46	Struvite Stones	Acute Renal Failure, urinary tract infection from Proteus mirabilis, hydronephrosis, staghorn calculi
47	Ectopic ACTH	Hypertension, obesity, facial fat deposition, striae, high cortisol not suppressed with either high dose or low dose dexamethasone suppression test
48	Drug-induced ATN/aminoglycoside toxicity	Acute Renal Failure, polyuria, gentamicin administration
49	Pseudohypoaldosteronism	Hyperkalemia, hyponatremia, non AG metabolic acidosis, high urine and serum aldosterone, high plasma renin activity
50	Thrombotic Thrombocytopenic Purpura (TTP)	Fever, lethargy, hematuria, proteinuria, low platelets, anemia

	Diagnosis	Key words
51	Xanthogranulomatous pyelonephritis	Female, recurrent urinary tract infections, flank pain, palpable unilateral renal mass
52	Renal tubular acidosis type IV (hyporeniniemic hypoaldosteronism)	Hyperkalemia, metabolic acidosis, low renin, low aldosterone
53	Oxalate stones	Obesity s/p gastric bypass, nephrolithiasis, hypercalciuria
54	Acute Interstitial Nephritis (AIN)	Acute Renal Failure, rash, arthralgia, fever, eosinophilia, U/Aà RBC, WBC
55	Preeclampsia	Pregnancy, hypertension, proteinuria, edema, elevated uric acid
56	Cushing's Disease	Hypertension, obesity, facial fat deposition, striae, high cortisol suppressed with high dose but not low dose dexamethasone suppression test
57	HIV-associated nephropathy (HIVAN)	Acute Renal Failure, African descent, Proteinuria, U/Sà Enlarged, ecogenic kidneys, biopsyà collapsing FSGS, normotensive, no edema
58	Pseudohyponatremia	Mild Hyponatremia, severe hyperglycemia
59	Gemcitabine toxicity	Acute Renal Failure, Biopsyà thrombotic microangiopathy, recent treatment for pancreatic cancer
60	Rhabdomyolysis	Seizure, Acute Renal Failure, hypokalemia, hypomagnesemia
61	Focal Segmental Glomerulosclerosis (FSGS) (tip variant)	Acute Renal Failure, proteinuria, edema, steroid responsive, biopsyà one glomerulus with swelling, vacuolation, and proliferation near proximal tubule
62	Adynamic bone disease	ESRD on HD, hip fracture, hypercalcemia, low/normal iPTH
63	Fabry's Disease	Male, CKD, polyuria, polydypsia, Angiokeratomas, CHF
64	Uric acid stones/Hyperuricosuria	Nephrolithiasis, obesity, diet high in animal protein, low urine pH
65	Thin basement membrane disease	Microhematuria, normal creatinine, family history of hematuria
66	X-linked hypophosphatemic rickets (XLHR)	Male, hypophosphatemia, phosphaturia, normal serum 1,25- OH Vit D, calcium, PTH , high alkaline phosphatase, bow-legged
67	Hepatorenal syndrome	Acute Renal Failure, hyponatremia, liver cirrhosis, ascites, low urinary sodium
68	Membranous nephropathy 2° colon cancer	Edema, proteinuria, Acute Renal Failure, weight loss, anemia, occult blood positive, abdominal fullness
69	Granulomatosis with polyangiitis	Progressive glomerulonephritis, fever, fatigue, epistaxis, c- ANCA/PR3-ANCA +
70	Nephronophthisis	Progressive CKD, young age of onset, rentinitis pigmentosa, U/Aà bland, no hematuria or proteinuria
71	Sjogren's syndrome	Interstitial nephritis, hypokalemia, distal RTA, dry eyes, dry mouth
72	Primary hypoparathyroidism	Hypocalcemia, hypomagnesemia, s/p thyroidectomy
73	Osteitis fibrosa (renal osteodystrophy)	ESRD on HD, high iPTH, high calcium, high phosphorus
74	Methotrexate toxicity	Acute Renal Failure, recent treatment for Acute Lymphoblastic Leukemia, normokalemia, normal phosphate
75	Syndrome of apparent mineralocorticoid excess (AME)	Hypertension, hypokalemia, metabolic alkalosis, low renin, low aldosterone
76	Bevacizumab toxicity	Acute Renal Failure, Low platelets, anemia, high LDH, biopsyà thrombotic microangiopathy, recent treatment for metastatic colorectal cancer
77	Renal vein thrombosis	Nephrotic syndrome, diuretic use, flank pain, hematuria, elevated LDH, U/Sà unilateral enlarged kidney
78	Acquired cystic kdney dsease (ACKD)	CKD, Flank pain, U/S shows bilateral cysts all <3cm, no family history of kidney disease

	Diagnosis	Key words
79	Primary hyperaldosteronism/Conn syndrome	Resistant Hypertension, hypokalemia, high plasma aldosterone concentration to plasma renin activity (high PAC/PRA)
80	Contrast-induced nephropathy	Acute Renal Failure on CKD, CT scan one day ago
81	Hypothyroidism	SIADH, lethargy, constipation, cold intolerance
82	Minimal change disease	Edema, sudden onset proteinuria, age 19
83	Obstrutive uropathy	Acute Renal Failure, BPH, U/Sà hydronephrosis
84	Fibromuscular dysplasia	Young woman, hypertension, renal artery stenosis on ultrasound
85	Multiple endocrine neoplasia type 2 (MEN I I)	Episodic hypertension with flushing, thyroid nodule, diarrhea
86	Tuberous sclerosis	Renal cysts, renal angiomyolipomas, hypertension, haratomatous tumors in multiple organ systems
87	Pheochromocytoma	Episodic hypertension with headache, sweating, tachycardia, diabetes, hypercalcemia, orthostatic hypotension
88	Antiphospholipid antibody syndrome	Renal Vein thrombosis, Acute Renal Failure, multiple spontaneous abortions
89	Sickle cell nephropathy	African descent, mild proteinuria, slowly progressive CKD, MPGN
90	Bartter's syndrome	Hypokalemia, metabolic alkalosis, normal urinary chloride, hypercalciuria
91	Membranous nephropathy 2° malaria	Edema, proteinuria, Acute Renal Failure, cyclic fever, recent travel to Brazilian rainforests
92	Lupus nephritis	Hematuria, proteinuria, joint inflammation, rash, ANA+, dsDNA+
93	Milk-alkali Syndrome/Calcium- alkali Syndrome	Hypercalcemia, hypophosphatemia, metabolic alkalosis, peptic ulcer disease (PUD)
94	Atheroembolic kidney disease	Male, smoker, Hypertension, s/p cardiac angiography, Acute Kidney Injury
95	Medulary sponge kidney	Hematuria, recurrent UTIs, multiple small stone nephrolithiasis, family history kidney disease, distal RTA
96	Lithium-induced hypercalcemia	CKD, hypercalcemia, bipolar disorder, no proteinuria
97	Microscopic polyangiitis (MPA)	Progressive glomerulonephritis, fevers, joint pain, p- ANCA/MPO-ANCA +
98	Central diabetes insipidus	Hypernatremia, low urinary osmolality, recent head injury, unresponsive to DDAVP
99	Bone marrow transplant nephropathy	History of bone marrow transplant, low platelets, high LDH, low haptoglobin, anemia, chronic renal failure, kidney biopsy showing thrombotic microangiopathy
100	Hemolytic uremic syndrome (HUS)	Fever, watery diarrhea, Acute Renal Failure, anemia, thrombocytopenia
101	Alport's syndrome	Male, microscopic hematuria, hearing loss
102	Propylene glycol poisoning	EtOH withdrawal on ativan gtt for several days with "banana bag," with new onset anion gap metabolic acidosis
103	Diabetic nephropathy	Hyperglycemia, microalbuminuria, diffuse mesangial expansion

Appendix 1: List of key words given to study participants. The first section is the blank keywords and the second is the answer key to the key words. (Section 2).

Google Instructions

Patients and medical personnel alike regularly use the internet to search for the answer to medical questions. The most often used search engine is Google, and the term "googling" has recently been added to the dictionary meaning "to search the internet using the Google website." The purpose of this experiment is to determine how well people with significant medical knowledge (medical residents) using the Google search engine compare with experts in the field of nephrology at the task of diagnosing kidney diseases given limited information in the way of medical key words.

Dr. Google's rules

1. You may use any combination of keywords given, or any interpretation of keywords (e.g. low C3/C4→hypocomplementemia).
2. You may only link to webpage returned on the first page of Google (i.e. the first 10 result pages).
3. You may only view the linked webpage, not any further links (i.e. you may not follow the trail of links- if its not there, its not there).
4. Be specific- Don't write nephritic syndrome, write focal segmental glomerular sclerosis/membranous/minimal change disease if you can. If you can not, write the most specific diagnosis you find on Google.
5. If a webpage presents you with a list of possible diagnoses, don't randomly guess one. See if other first page Google results can help.

Appendix 2: Instruction page given to all "googlers" when asked to participate.

Open Peer Review

Current Peer Review Status: ? ✓

Version 1

Reviewer Report 19 March 2013

https://doi.org/10.5256/f1000research.1254.r839

✓ **Melanie Hoenig**
Renal Unit, Joslin Diabetes Center, Boston, Boston, MA, USA

I enjoyed the article and was particularly pleased that the authors provided sufficient examples of the keywords used in queries. The commentary was balanced. It is worth noting that while 'Dr. Google' may be helpful in identifying the diagnosis once provided with the keywords or search term, it takes a clinician to be able to sort through the detailed history, physical examination and laboratory data to determine which aspects of the presentation are worth using for a “search.”

Competing Interests: No competing interests were disclosed.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 19 March 2013

https://doi.org/10.5256/f1000research.1254.r852

? **Rudy Bilous**
Academic Centre, James Cook University Hospital, Middlesbrough, UK

This is an intriguing report but the approach is a bit simplistic. Atypical presentations of common conditions are more frequently encountered than typical presentations of rare ones. Thus it is really hard to test the hypothesis fully. The internet is more likely to throw up rare options that may result in unnecessary and perhaps dangerous and costly investigations. The fellows are on a journey of

understanding and without the experience are likely to score slightly less well than Dr Google. The authors have also made many comparisons and do not appear to have adjusted the level of statistical significance.

Competing Interests: No competing interests were disclosed.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Comments on this article

Version 1

Author Response 20 Mar 2013

Kenar Jhaveri, North Shore University Hospital and Long Island Jewish Medical Centre, Hofstra North Shore LIJ School of Medicine, Great Neck, NY, USA

Thanks for the two referee reports and interest in our article. We agreed that atypical presentations of common conditions are more frequent than rare diseases. Both residents and fellows are in the journey of learning and personal knowledge biases cannot be excluded. We feel that this is a limitation of our manuscript and have added a sentence to mention specifically of your concerns. While we feel that googlers might have gotten to the level of fellows in rare diseases, we do feel that it is the *thinking* that is most important and *a physicians's knowledge* and *experience* cannot be replaced by a search engine. We do mention that towards the end in the discussion.

Competing Interests: No competing interests were disclosed.