SHORT RESEARCH ARTICLE

Paging Doctor Google! Heuristics vs. technology [version 1; referees: 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.

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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\(^1\). 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\(^1\), 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.\(^1\).

As technology infiltrates everyday medicine, the debate about the appropriate role for information technology within medicine has intensified\(^5\). Early on, concern was raised regarding the utility of search engines to direct patients and clinicians to relevant sources\(^5\). 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. 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. 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\(^5\). 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\(^6\). Using this approach, the Google search provided the correct diagnosis in 58% of the cases\(^6\). 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.
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\(^1\) 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.
References


<table>
<thead>
<tr>
<th></th>
<th>Key Words</th>
<th>Disease</th>
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<tbody>
<tr>
<td>1</td>
<td>Young adults, proteinuria, hematuria, drusen in eye, decreased C3 and C4</td>
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<td>2</td>
<td>Altered Mental Status, lactic acidosis, other members of household with headache, mild confusion, nausea</td>
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<td>3</td>
<td>Severe Hypertension, Rapidly progressive Acute Renal Failure, rapid skin thickening, high renin</td>
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<td>4</td>
<td>Hypocalcemia, hypophosphatemia, s/p parathyroidectomy</td>
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<td>5</td>
<td>Proteinuria, hematuria, acute renal failure, history of Chronic Lymphocytic Leukemia, unusual deposits on kidney biopsy</td>
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<td>6</td>
<td>Slowly rising creatinine, hematuria, proteinuria, low C3</td>
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<td>7</td>
<td>Severe Hypertension, hypokalemia, metabolic alkalosis, low serum aldosterone</td>
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<td>Metabolic acidosis, urine pH &gt; 5.5, positive urine anion gap</td>
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<td>Progressive Renal Failure, proteinuria, hypocomplementemia, high AST/ALT, cryoglobulinemia</td>
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<td>Back pain, Acute Renal Failure, hypercalcemia, anemia</td>
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<td>Fever, Cough, dysuria, microscopic hematuria, Acute Renal Failure, normal complement</td>
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<td>Oliguric Acute Renal Failure, glomerulonephritis, pulmonary hemorrhage, anti-GBM Ab+</td>
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<td>Acute Renal Failure, recent treatment for Acute Lymphoblastic Leukemia, hyperuricemia, hyperkalemia, hyperphosphatemia, metabolic acidosis</td>
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<td>15</td>
<td>Hypernatremia, geriatric, no thirst, high urine osmolality, brain mass on CT</td>
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<td>Fever, lethargy, muscle pain, Acute Renal Failure, proteinuria, edema, aplastic anemia</td>
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<td>17</td>
<td>Abrupt onset of Hypertension, recurrent flash pulmonary edema, U/Sà asymmetric kidney size</td>
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<td>18</td>
<td>Hyponatremia, euvoelma, low plasma osmolality, high urine osmolality</td>
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<td>CKD, increased PTH, decreased 1,25-OH Vit D, hyperphosphatemia</td>
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<td>Acute Renal Failure, HIV, nephrogenic diabetes incipidus, hypomagnesemia</td>
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<td>Hypernatremia, low urinary osmolality, urine osmolality increases with DDAVP</td>
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<td>Metabolic acidosis, high anion gap, hyperglycemia</td>
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<td>Hypercalcemia, low PTH, lung nodule</td>
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<td>Acidosis, aminoaciduria, glycosuria, hypouricemia, hypophosphatemia</td>
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<td>African American, Acute Renal Failure, proteinuria, edema, Hypertension, obese</td>
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<td>Hypercalcemia, recurrent kidney stones, hyperparathyroidism, recurrent hypoglycemia, pituitary adenoma</td>
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<td>Intoxicated, metabolic gap acidosis, urineàoxalate crystals, no ketones</td>
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<td>29</td>
<td>Hypercalcemia, hypercalciuria, bilateral pulmonary hilar adenopathy, heart block</td>
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<td>Key Words</td>
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<td>30</td>
<td>Hypotension, hyperkalemia, hypoglycemia, metabolic acidosis, hypercalcemia, hyponatremia</td>
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<td>31</td>
<td>Advanced CKD, ataxia, blurry vision, alopecia, takes multiple supplements from health food store</td>
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<td>32</td>
<td>Acute Renal Failure, asthma, eosinophilia</td>
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<td>33</td>
<td>Hyponatremia, increased thirst, polyuria, low serum and urine osmolality</td>
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<td>34</td>
<td>ESRD, carpal tunnel syndrome, shoulder arthralgia, subchondral bone cysts on x-ray</td>
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<td>35</td>
<td>Renal Failure, proteinuria, new CHF, biopsy w/mesangial nodules, elevated free lambda light chain</td>
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<td>36</td>
<td>Intoxicated, anion gap metabolic acidosis, normal osmolar gap</td>
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<td>37</td>
<td>Acute Renal Failure, headaches, IgM spike on immunofixation, hepatosplenomegaly, amyloidosis on kidney biopsy</td>
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<td>38</td>
<td>Cerebellar and retinal hemangioblastoma, pancreatic cyst, renal cysts</td>
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<td>39</td>
<td>Metabolic acidosis, bicarbonaturia with bicarbonate supplementation</td>
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<td>40</td>
<td>Bilateral flank pain, Hypertension, Family History Kidney Disease, RUQ U/S with multiple liver cysts</td>
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<td>41</td>
<td>Alcoholic pancreatitis s/p NPO for 8 days, hypophosphatemia, hypokalemia, hypomagnesemia</td>
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<td>42</td>
<td>Acute Renal Failure, nephrotic syndrome hypocomplementemia, high AST/ALT, biopsyà membranous glomerulopathy</td>
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<td>43</td>
<td>Fungemia, nonoliguric Acute Renal Failure, hypokalemia, hypomagnesemia, dilute urine</td>
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<td>44</td>
<td>Hypokalemia, metabolic alkalosis, mild hypotension, hypocalciuria, hypomagnesemia</td>
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<td>45</td>
<td>Hematuria, eosinophilia, urine microscopyà eggs</td>
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<td>Acute Renal Failure, urinary tract infection from Proteus mirabilis, hydronephrosis, staghorn calculi</td>
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<td>47</td>
<td>Hypertension, obesity, facial fat deposition, striae, high cortisol not suppressed with either high dose or low dose dexamethasone suppression test</td>
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<td>48</td>
<td>Acute Renal Failure, polyuria, gentamicin administration</td>
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<td>Hyperkalemia, hyponatremia, non AG metabolic acidosis, high urine and serum aldosterone, high plasma renin activity</td>
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<td>50</td>
<td>Fever, lethargy, hematuria, proteinuria, low platelets, anemia</td>
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<td>51</td>
<td>Female, recurrent urinary tract infections, flank pain, palpable unilateral renal mass</td>
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<td>52</td>
<td>Hyperkalemia, metabolic acidosis, low renin, low aldosterone</td>
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<td>53</td>
<td>Obesity s/p gastric bypass, nephrolithiasis, hypercalciuria</td>
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<td>Acute Renal Failure, rash, arthralgia, fever, eosinophilia, U/Aà RBC, WBC</td>
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<td>Pregnancy, hypertension, proteinuria, edema, elevated uric acid</td>
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<td>Hypertension, obesity, facial fat deposition, striae, high cortisol suppressed with high dose but not low dose dexamethasone suppression test</td>
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<td>Acute Renal Failure, African descent, Proteinuria, U/Sà Enlarged, ecogenic kidneys, biopsyà collapsing FSGS, normotensive, no edema</td>
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<td>Key Words</td>
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<td>58 Mild Hyponatremia, severe hyperglycemia</td>
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<td>59 Acute Renal Failure, Biopsyà thrombotic microangiopathy, recent treatment for pancreatic cancer</td>
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<td>60 Seizure, Acute Renal Failure, hypokalemia, hypomagnesemia</td>
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<td>61 Acute Renal Failure, proteinuria, edema, steroid responsive, biopsyà one glomerulus with swelling, vacuolation, and proliferation near proximal tubule</td>
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<td>62 ESRD on HD, hip fracture, hypercalcemia, low/normal iPTH</td>
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<td>63 Male, CKD, polyuria, polydypsia, Angiokeratomas, CHF</td>
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<td>64 Nephrolithiasis, obesity, diet high in animal protein, low urine pH</td>
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<td>65 Microhematuria, normal creatinine, family history of hematuria</td>
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<td>66 Male, hypophosphatemia, phosphaturia, normal serum 1,25-OH Vit D, calcium, PTH , high alkaline phosphatase, bow-legged</td>
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<td>67 Acute Renal Failure, hyponatremia, liver cirrhosis, ascites, low urinary sodium</td>
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<td>68 Edema, proteinuria, Acute Renal Failure, weight loss, anemia, occult blood positive, abdominal fullness</td>
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<td>69 Progressive glomerulonephritis, fever, fatigue, epistaxis, c-ANCA/PR3-ANCA +</td>
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<td>70 Progressive CKD, young age of onset, retinitis pigmentosa, U/A à bland, no hematuria or proteinuria</td>
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<td>71 Interstitial nephritis, hypokalemia, distal RTA, dry eyes, dry mouth</td>
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<td>72 Hypocalcemia, hypomagnesemia, s/p thyroidectomy</td>
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<td>73 ESRD on HD, high iPTH, high calcium, high phosphorus</td>
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<td>74 Acute Renal Failure, recent treatment for Acute Lymphoblastic Leukemia, normokalemia, normal phosphate</td>
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<td>75 Hypertension, hypokalemia, metabolic alkalosis, low renin, low aldosterone</td>
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<td>76 Acute Renal Failure, Low platelets, anemia, high LDH, biopsyà thrombotic microangiopathy, recent treatment for metastatic colorectal cancer</td>
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<td>77 Nephrotic syndrome, diuretic use, flank pain, hematuria, elevated LDH, U/Sà unilateral enlarged kidney</td>
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<td>78 CKD, Flank pain, U/S shows bilateral cysts all &lt;3 cm, no family history of kidney disease</td>
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<td>79 Resistant Hypertension, hypokalemia, high plasma aldosterone concentration to plasma renin activity (high PAC/PRA)</td>
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<td>80 Acute Renal Failure on CKD, CT scan one day ago</td>
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<td>81 SIADH, lethargy, constipation, cold intolerance</td>
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<td>82 Edema, sudden onset proteinuria, age 19</td>
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<td>83 Acute Renal Failure, BPH, U/Sà hydronephrosis</td>
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<td>84 Young woman, hypertension, renal artery stenosis on ultrasound</td>
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<td>85 Episodic hypertension with flushing, thyroid nodule, diarrhea</td>
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<tr>
<td>86 Renal cysts, renal angiomyolipomas, hypertension, haratomatous tumors in multiple organ systems</td>
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<td>Key Words</td>
<td>Disease</td>
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<td>87  Episodic hypertension with headache, sweating, tachycardia, diabetes,</td>
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<td>hypercalcemia, orthostatic hypotension</td>
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<td>88  Renal Vein thrombosis, Acute Renal Failure, multiple spontaneous births</td>
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<td>89  African descent, mild proteinuria, slowly progressive CKD, MPGN</td>
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<td>90  Hypokalemia, metabolic alkalosis, normal urinary chloride, hypercalcemia</td>
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<td>91  Edema, proteinuria, Acute Renal Failure, cyclic fever, recent travel</td>
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<td>to Brazilian rainforests</td>
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<td>92  hematuria, proteinuria, joint inflammation, rash, ANA+, dsDNA+</td>
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<td>93  Hypercalcemia, hypophosphatemia, metabolic alkalosis, peptic ulcer</td>
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<td>disease (PUD)</td>
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<td>94  Male, smoker, Hypertension, s/p cardiac angiography, Acute Kidney</td>
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<td>Injury</td>
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<td>history kidney disease, distal RTA</td>
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<td>96  CKD, hypercalcemia, bipolar disorder, no proteinuria</td>
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<tr>
<td>97  Progressive glomerulonephritis, fevers, joint pain, p-ANCA/MPO-ANCA+</td>
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<tr>
<td>98  Hypernatremia, low urinary osmolality, recent head injury, unresponsive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to DDAVP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99  History of bone marrow transplant, low platelets, high LDH, low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>haptoglobin, anemia, chronic renal failure, kidney biopsy showing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>thrombotic microangiopathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 Fever, watery diarrhea, Acute Renal Failure, anemia, thrombocytopenia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101 Male, microscopic hematuria, hearing loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>102 EtOH withdrawal on Ativan gtt for several days with “banana bag,”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with new onset anion gap metabolic acidosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>103 Hyperglycemia, microalbuminuria, diffuse mesangial expansion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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).**
<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Key words</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Dense Deposit Disease</td>
<td>Young adults, proteinuria, hematuria, drusen in eye, decreased C3 and C4</td>
</tr>
<tr>
<td>2 Carbon monoxide poisoning</td>
<td>Altered Mental Status, lactic acidosis, other members of household with</td>
</tr>
<tr>
<td></td>
<td>headache, mild confusion, nausea</td>
</tr>
<tr>
<td>3 Scleroderma Renal Crisis</td>
<td>Severe Hypertension, rapidly progressive Acute Renal Failure, rapid skin</td>
</tr>
<tr>
<td></td>
<td>thickening, high renin</td>
</tr>
<tr>
<td>4 Hungry Bone Syndrome</td>
<td>Hypocalcemia, hypophosphatemia, s/p parathyroidectomy</td>
</tr>
<tr>
<td>5 Immunotactoid glomerulonephritis</td>
<td>Proteinuria, hematuria, acute renal failure, history of chronic lymphocytic</td>
</tr>
<tr>
<td></td>
<td>leukemia, unusual deposits on kidney biopsy</td>
</tr>
<tr>
<td>6 Membranoproliferative glomerulonephritis (MPGN) type 1</td>
<td>Slowly rising creatinine, hematuria, proteinuria, low C3</td>
</tr>
<tr>
<td>7 Liddle’s Syndrome (pseudohyperaldosteronism)</td>
<td>Severe hypertension, hypokalemia, metabolic alkalosis, low serum aldosterone</td>
</tr>
<tr>
<td>8 Renal tubular acidosis type 1 (Distal RTA-Classic)</td>
<td>Metabolic acidosis, urine pH &gt; 5.5, positive urine anion gap</td>
</tr>
<tr>
<td>9 Hep C virus-related glomerulopathy</td>
<td>Progressive renal failure, proteinuria, hypocomplementemia, high AST/ALT,</td>
</tr>
<tr>
<td></td>
<td>cryoglobulinemia</td>
</tr>
<tr>
<td>10 Multiple myeloma</td>
<td>Back pain, acute renal failure, hypercalcemia, anemia</td>
</tr>
<tr>
<td>11 IgA Nephropathy</td>
<td>Fever, Cough, dysuria, microscopic hematuria, Acute Renal Failure, normal</td>
</tr>
<tr>
<td></td>
<td>complement</td>
</tr>
<tr>
<td>12 Goodpasture’s Syndrome</td>
<td>Oliguric Acute Renal Failure, glomerulonephritis, pulmonary hemorrhage,</td>
</tr>
<tr>
<td></td>
<td>anti-GBM Ab+</td>
</tr>
<tr>
<td>13 Tumor lysis Syndrome</td>
<td>Acute renal failure, recent treatment for Acute Lymphoblastic Leukemia,</td>
</tr>
<tr>
<td></td>
<td>hyperuricemia, hyperkalemia, hyperphosphatemia, metabolic acidosis</td>
</tr>
<tr>
<td>14 Lead Nephropathy</td>
<td>Slowly progressive CKD, hyperuricemia, hypertension, works as a mechanic</td>
</tr>
<tr>
<td>15 Adipsic Hyponatremia</td>
<td>Hyponatremia, geriatric, no thirst, high urine osmolality, brain mass on CT</td>
</tr>
<tr>
<td>16 Focal Segmental Glomerulosclerosis (FSGS) (collapsing variant) 2° parvovirus B19</td>
<td>Abrupt onset of Hypertension, recurrent flash pulmonary edema, U/Sà</td>
</tr>
<tr>
<td></td>
<td>asymmetric kidney size</td>
</tr>
<tr>
<td>17 Syndrome of inappropriate antidiuretic hormone (SIADH)</td>
<td>Hyponatremia, euvoelemia, low plasma osmolality, high urine osmolality</td>
</tr>
<tr>
<td>18 Secondary hyperparathyroidism</td>
<td>CKD, increased PTH, decreased 1,25-OH Vit D, hyperphosphatemia</td>
</tr>
<tr>
<td>19 Foscarnet Toxicity</td>
<td>Acute Renal Failure, HIV, nephrogenic diabetes incipidus, hypomagnesemia</td>
</tr>
<tr>
<td>20 Nephrogenic Diabetes insipidus</td>
<td>Hyponatremia, low urinary osmolality, urine osmolality increases with DDAVP</td>
</tr>
<tr>
<td>21 Diabetic Ketoacidosis</td>
<td>Metabolic acidosis, high anion gap, hyperglycemia</td>
</tr>
<tr>
<td>22 Humoral hypercalcemia of malignancy</td>
<td>Hypercalcemia, low PTH, lung nodule</td>
</tr>
<tr>
<td>23 Fanconi’s Syndrome</td>
<td>Acidosis, aminoaciduria, glycosuria, hypouricemia, hypophosphatemia</td>
</tr>
<tr>
<td>24 Post-infectious GN (Post-strep GN)</td>
<td>Acute Renal Failure, Hematuria, Hypertension, pulmonary edema, sore throat</td>
</tr>
<tr>
<td></td>
<td>2 weeks ago</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Key words</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>26 Focal Segmental Glomerulosclerosis (FSGS), primary</td>
<td>African, American, Acute Renal Failure, proteinuria, edema, Hypertension, obese</td>
</tr>
<tr>
<td>27 Multiple Endocrine Neoplasia type 1 (MEN I)</td>
<td>Hypercalcemia, recurrent kidney stones, hyperparathyroidism, recurrent hypoglycemia, pituitary adenoma</td>
</tr>
<tr>
<td>28 Ethylene glycol poisoning</td>
<td>Intoxicated, metabolic gap acidosis, urine oxalate crystals, no ketones</td>
</tr>
<tr>
<td>29 Sarcoïdosis</td>
<td>Hypercalcemia, hypercalciuria, bilateral pulmonary hilar adenopathy, heart block</td>
</tr>
<tr>
<td>30 Adrenal Insufficiency</td>
<td>Hypotension, hyperkalemia, hypoglycemia, metabolic acidosis, hypercalciemia, hyponatremia</td>
</tr>
<tr>
<td>31 Vitamin A intoxication (chronic)</td>
<td>Advanced CKD, ataxia, blurry vision, alopecia, takes multiple supplements from health food store</td>
</tr>
<tr>
<td>32 Churgh-Strauss syndrome</td>
<td>Acute Renal Failure, asthma, eosinophilia</td>
</tr>
<tr>
<td>33 Psychogenic polydypsia</td>
<td>Hyponatremia, increased thirst, polyuria, low serum and urine osmolality</td>
</tr>
<tr>
<td>34 Osteoarticular Amyloidosis</td>
<td>ESRD, carpal tunnel syndrome, shoulder arthalgia, subchondral bone cysts on x-ray</td>
</tr>
<tr>
<td>35 Primary Amyloidosis (AL-type)</td>
<td>Renal Failure, proteinuria, new CHF, biopsy w/ mesangial nodules, elevated free lambda light chain</td>
</tr>
<tr>
<td>36 Isopropyl alcohol poisoning</td>
<td>Intoxicated, anion gap metabolic acidosis, normal osmolar gap</td>
</tr>
<tr>
<td>37 Waldenstrom’s Macroglobulinemia</td>
<td>Acute Renal Failure, headaches, IgM spike on immunofixation, hepatosplenomegaly, amyloidosis on kidney biopsy</td>
</tr>
<tr>
<td>38 Von Hippel-Lindau syndrome</td>
<td>Cerebellar and retinal hemangioblastoma, pancreatic cyst, renal cysts</td>
</tr>
<tr>
<td>39 Renal tubular acidosis type II (Proximal RTA)</td>
<td>Metabolic acidosis, bicarbonaturia with bicarbonate supplementation</td>
</tr>
<tr>
<td>40 Autosomal Dominant Polycystic Kidney Disease (ADPKD)</td>
<td>Bilateral flank pain, Hypertension, Family History Kidney Disease, RUQ U/S with multiple liver cysts</td>
</tr>
<tr>
<td>41 Refeeding Syndrome</td>
<td>Alcoholic pancreatitis s/p NPO for 8 days, hypophosphatemia, hypokalemia, hypomagnesemia</td>
</tr>
<tr>
<td>42 Hep B virus-related glomerulopathy</td>
<td>Acute Renal Failure, nephrotic syndrome hypocomplementemia, high AST/ALT, biopsy membranous glomerulopathy</td>
</tr>
<tr>
<td>43 Amphotericin B toxicity</td>
<td>Fungemia, nonoliguric Acute Renal Failure, hypokalemia, hypomagnesemia, dilute urine</td>
</tr>
<tr>
<td>44 Gitelman’s Syndrome</td>
<td>Hypokalemia, metabolic alkalosis, mild hypotension, hypocalciuria, hypomagnesemia</td>
</tr>
<tr>
<td>45 Schistosomiasis</td>
<td>Hematuria, eosinophilia, urine microscopy ã eggs</td>
</tr>
<tr>
<td>46 Struvite Stones</td>
<td>Acute Renal Failure, urinary tract infection from Proteus mirabilis, hydronephrosis, staghorn calculi</td>
</tr>
<tr>
<td>47 Ectopic ACTH</td>
<td>Hypertension, obesity, facial fat deposition, striae, high cortisol not suppressed with either high dose or low dose dexamethasone suppression test</td>
</tr>
<tr>
<td>48 Drug-induced ATN/aminoglycoside toxicity</td>
<td>Acute Renal Failure, polyuria, gentamicin administration</td>
</tr>
<tr>
<td>49 Pseudohypoaldosteronism</td>
<td>Hyperkalemia, hyponatremia, non AG metabolic acidosis, high urine and serum aldosterone, high plasma renin activity</td>
</tr>
<tr>
<td>50 Thrombotic Thrombocytopenic Purpura (TTP)</td>
<td>Fever, lethargy, hematuria, proteinuria, low platelets, anemia</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Key words</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>51 Xanthogranulomatous pyelonephritis</td>
<td>Female, recurrent urinary tract infections, flank pain, palpable unilateral renal mass</td>
</tr>
<tr>
<td>52 Renal tubular acidosis type IV (hyporeniniemic hypoaldosteronism)</td>
<td>Hyperkalemia, metabolic acidosis, low renin, low aldosterone</td>
</tr>
<tr>
<td>53 Oxalate stones</td>
<td>Obesity s/p gastric bypass, nephrolithiasis, hypercalciuria</td>
</tr>
<tr>
<td>54 Acute Interstitial Nephritis (AIN)</td>
<td>Acute Renal Failure, rash, arthralgia, fever, eosinophilia, U/Aà RBC, WBC</td>
</tr>
<tr>
<td>55 Preeclampsia</td>
<td>Pregnancy, hypertension, proteinuria, edema, elevated uric acid</td>
</tr>
<tr>
<td>56 Cushing’s Disease</td>
<td>Hypertension, obesity, facial fat deposition, striae, high cortisol suppressed with high dose but not low dose dexamethasone suppression test</td>
</tr>
<tr>
<td>57 HIV-associated nephropathy (HIVAN)</td>
<td>Acute Renal Failure, African descent, Proteinuria, U/Sà Enlarged, ecogenic kidneys, biopsyà collapsing FSGS, normotensive, no edema</td>
</tr>
<tr>
<td>58 Pseudohiponatremia</td>
<td>Mild Hyponatremia, severe hyperglycemia</td>
</tr>
<tr>
<td>59 Gemcitabine toxicity</td>
<td>Acute Renal Failure, Biopsyà thrombotic microangiopathy, recent treatment for pancreatic cancer</td>
</tr>
<tr>
<td>60 Rhabdomyolysis</td>
<td>Seizure, Acute Renal Failure, hypokalemia, hypomagnesemia</td>
</tr>
<tr>
<td>61 Focal Segmental Glomerulosclerosis (FSGS) (tip variant)</td>
<td>Acute Renal Failure, proteinuria, edema, steroid responsive, biopsyà one glomerulus with swelling, vacuolation, and proliferation near proximal tubule</td>
</tr>
<tr>
<td>62 Adynamic bone disease</td>
<td>ESRD on HD, hip fracture, hypercalcemia, low/normal iPTH</td>
</tr>
<tr>
<td>63 Fabry’s Disease</td>
<td>Male, CKD, polyuria, polydypsia, Angiokeratomas, CHF</td>
</tr>
<tr>
<td>64 Uric acid stones/Hyperuricosuria</td>
<td>Nephrolithiasis, obesity, diet high in animal protein, low urine pH</td>
</tr>
<tr>
<td>65 Thin basement membrane disease</td>
<td>Microhernatemia, normal creatinine, family history of hematuria</td>
</tr>
<tr>
<td>66 X-linked hypophosphatemic rickets (XLHR)</td>
<td>Male, hypophosphatemia, phosphaturia, normal serum 1,25- OH Vit D, calcium, PTH , high alkaline phosphatase, bow-legged</td>
</tr>
<tr>
<td>67 Hepatorenal syndrome</td>
<td>Acute Renal Failure, hyponatremia, liver cirrhosis, ascites, low urinary sodium</td>
</tr>
<tr>
<td>68 Membranous nephropathy 2° colon cancer</td>
<td>Edema, proteinuria, Acute Renal Failure, weight loss, anemia, occult blood positive, abdominal fullness</td>
</tr>
<tr>
<td>69 Granulomatosis with polyangiitis</td>
<td>Progressive glomerulonephritis, fever, fatigue, epistaxis, c- ANCA/PR3-ANCA +</td>
</tr>
<tr>
<td>70 Nephronphthisis</td>
<td>Progressive CKD, young age of onset, rinitis pigmentosa, U/Aà bland, no hematuria or proteinuria</td>
</tr>
<tr>
<td>71 Sjogren’s syndrome</td>
<td>Interstitial nephritis, hypokalemia, distal RTA, dry eyes, dry mouth</td>
</tr>
<tr>
<td>72 Primary hypoparathyroidism</td>
<td>Hypocalcemia, hypomagnesemia, s/p thyroidectomy</td>
</tr>
<tr>
<td>73 Osteitis fibrosa (renal osteodystrophy)</td>
<td>ESRD on HD, high iPTH, high calcium, high phosphorus</td>
</tr>
<tr>
<td>74 Methotrexate toxicity</td>
<td>Acute Renal Failure, recent treatment for Acute Lymphoblastic Leukemia, normokalemia, normal phosphate</td>
</tr>
<tr>
<td>75 Syndrome of apparent mineralocorticoid excess (AME)</td>
<td>Hypertension, hypokalemia, metabolic alkalosis, low renin, low aldosterone</td>
</tr>
<tr>
<td>76 Bevacizumab toxicity</td>
<td>Acute Renal Failure, Low platelets, anemia, high LDH, biopsyà thrombotic microangiopathy, recent treatment for metastatic colorectal cancer</td>
</tr>
<tr>
<td>77 Renal vein thrombosis</td>
<td>Nephrotic syndrome, diuretic use, flank pain, hematuria, elevated LDH, U/Sà unilateral enlarged kidney</td>
</tr>
<tr>
<td>78 Acquired cystic kidney disease (ACKD)</td>
<td>CKD, Flank pain, U/S shows bilateral cysts all &lt;3cm, no family history of kidney disease</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Key words</td>
</tr>
<tr>
<td>-----------</td>
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</tr>
<tr>
<td>79 Primary hyperaldosteronism/Conn syndrome</td>
<td>Resistant Hypertension, hypokalemia, high plasma aldosterone concentration to plasma renin activity (high PAC/PRA)</td>
</tr>
<tr>
<td>80 Contrast-induced nephropathy</td>
<td>Acute Renal Failure on CKD, CT scan one day ago</td>
</tr>
<tr>
<td>81 Hypothyroidism</td>
<td>SIADH, lethargy, constipation, cold intolerance</td>
</tr>
<tr>
<td>82 Minimal change disease</td>
<td>Edema, sudden onset proteinuria, age 19</td>
</tr>
<tr>
<td>83 Obstructive uropathy</td>
<td>Acute Renal Failure, BPH, U/Sâ hydronephrosis</td>
</tr>
<tr>
<td>84 Fibromuscular dysplasia</td>
<td>Young woman, hypertension, renal artery stenosis on ultrasound</td>
</tr>
<tr>
<td>85 Multiple endocrine neoplasia type 2 (MEN II)</td>
<td>Episodic hypertension with flushing, thyroid nodule, diarrhea</td>
</tr>
<tr>
<td>86 Tuberous sclerosis</td>
<td>Renal cysts, renal angiomyolipomas, hypertension, haratomatous tumors in multiple organ systems</td>
</tr>
<tr>
<td>87 Pheochromocytoma</td>
<td>Episodic hypertension with headache, sweating, tachycardia, diabetes, hypercalcemia, orthostatic hypotension</td>
</tr>
<tr>
<td>88 Antiphospholipid antibody syndrome</td>
<td>Renal Vein thrombosis, Acute Renal Failure, multiple spontaneous abortions</td>
</tr>
<tr>
<td>89 Sickle cell nephropathy</td>
<td>African descent, mild proteinuria, slowly progressive CKD, MPGN</td>
</tr>
<tr>
<td>90 Bartter’s syndrome</td>
<td>Hypokalemia, metabolic alkalosis, normal urinary chloride, hypercalciuria</td>
</tr>
<tr>
<td>91 Membranous nephropathy 2° malaria</td>
<td>Edema, proteinuria, Acute Renal Failure, cyclic fever, recent travel to Brazilian rainforests</td>
</tr>
<tr>
<td>92 Lupus nephritis</td>
<td>Hematuria, proteinuria, joint inflammation, rash, ANA+, dsDNA+</td>
</tr>
<tr>
<td>93 Milk-alkali Syndrome/Calcium- alkali Syndrome</td>
<td>Hypercalcemia, hypophosphatemia, metabolic alkalosis, peptic ulcer disease (PUD)</td>
</tr>
<tr>
<td>94 Atheroembolic kidney disease</td>
<td>Male, smoker, Hypertension, s/p cardiac angiography, Acute Kidney Injury</td>
</tr>
<tr>
<td>95 Medulary sponge kidney</td>
<td>Hematuria, recurrent UTIs, multiple small stone nephrolithiasis, family history kidney disease, distal RTA</td>
</tr>
<tr>
<td>96 Lithium-induced hypercalcemia</td>
<td>CKD, hypercalcemia, bipolar disorder, no proteinuria</td>
</tr>
<tr>
<td>97 Microscopic polyangiitis (MPA)</td>
<td>Progressive glomerulonephritis, fevers, joint pain, p- ANCA/MPO-ANCA +</td>
</tr>
<tr>
<td>98 Central diabetes insipidus</td>
<td>Hypernatremia, low urinary osmolality, recent head injury, unresponsive to DDAVP</td>
</tr>
<tr>
<td>99 Bone marrow transplant nephropathy</td>
<td>History of bone marrow transplant, low platelets, high LDH, low haptoglobin, anemia, chronic renal failure, kidney biopsy showing thrombotic microangiopathy</td>
</tr>
<tr>
<td>100 Hemolytic uremic syndrome (HUS)</td>
<td>Fever, watery diarrhea, Acute Renal Failure, anemia, thrombocytopenia</td>
</tr>
<tr>
<td>101 Alport’s syndrome</td>
<td>Male, microscopic hematuria, hearing loss</td>
</tr>
<tr>
<td>102 Propylene glycol poisoning</td>
<td>EtOH withdrawal on ativan gtt for several days with “banana bag,” with new onset anion gap metabolic acidosis</td>
</tr>
<tr>
<td>103 Diabetic nephropathy</td>
<td>Hyperglycemia, microalbuminuria, diffuse mesangial expansion</td>
</tr>
</tbody>
</table>

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).
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.
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.”

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.

**Competing Interests:** No competing interests were disclosed.

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.

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.

**Competing Interests:** No competing interests were disclosed.
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 physician’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.