Clinical–Pathological Conference

Hypertension and Its Complications in a Young Man With Autoimmune Disease

Eve Miller-Hodges, Anna F. Dominiczak, Garry L.R. Jennings, Suzanne Oparil, Daniel C. Batlle, Fernando Elijovich, Jan N. Basile, Cheryl L. Laffer, Anna Oliveras, Neeraj Dhaun

A 30-year-old man, who had moved to the United Kingdom from South Asia, was referred to the renal clinic with nephrotic syndrome. He had recently been diagnosed with systemic lupus erythematosus (SLE) after presenting to the rheumatology clinic with joint pain, skin rash, and pleuritic chest pain and fulfilling 8 of 17 SLICC (Systemic Lupus International Collaborating Clinics) diagnostic criteria. His immunology was in keeping with active SLE: his complement levels were low, and he had antibodies against double-stranded DNA and extractable nuclear antigens (Table S1A in the online-only Data Supplement).

Our patient had heavy proteinuria (3.9 g/d) and a low serum albumin (25 g/L) in keeping with the nephrotic syndrome. Although his excretory renal function was normal, he had microhematuria (3+) on urinalysis. An urgent renal tract ultrasound with Doppler revealed that he had a preexistent renal vein thrombosis for which he was anticoagulated. In the absence of any serological evidence of antiphospholipid syndrome, this was attributed to his nephrotic syndrome. He went on to have a renal biopsy. This demonstrated classes III (focal proliferative) and V (membranous) lupus nephritis (Figure 1).

The online-only Data Supplement is available with this article at http://hyper.ahajournals.org/lookup/suppl/doi:10.1161/HYPTENSIONHA.117.09036/-/DC1. Correspondence to Neeraj Dhaun, University/BHF Centre for Cardiovascular Science, University of Edinburgh, The Queen's Medical Research Institute, 47 Little France Crescent, Edinburgh, EH16 4TJ, United Kingdom. E-mail bean.dhaun@ed.ac.uk

Hypertension is available at http://hyper.ahajournals.org
DOI: 10.1161/HYPTENSIONHA.117.09036

At presentation, his blood pressure (BP) was 126/88 mm Hg in the absence of antihypertensive treatment. Although this lay within both UK and US recommended guidelines, we recognize that given this man’s age and heavy proteinuria, a lower BP target may have been beneficial.\(^3\)

Management of Lupus Nephritis

Our patient started standard induction immunosuppressive treatment for lupus nephritis comprising of glucocorticoids and pulsed intravenous cyclophosphamide.\(^4\) However, his disease proved difficult to manage over the next 2 years. He tolerated only a short course of cyclophosphamide because of an anaphylactoid reaction, subsequently attributed to the mesna component (given to protect the bladder epithelium). Alternative induction therapy with mycophenolate was not tolerated because of gastrointestinal side effects. Switching this to an enteric preparation of mycophenolate (myfortic) made little impact on disease activity after 6 months. Similarly, 3 months of azathioprine had little effect. He was finally treated with the anti-CD20 B-cell–depleting monoclonal antibody, rituximab.

Over these 2 years our patient’s lupus nephritis failed to enter remission, and his renal function gradually deteriorated (Figure 2). He remained nephrotic with \(\approx 10\) g/d of proteinuria and a serum albumin of \(< 20\) g/L (2.0 g/dL). Given his increased thrombotic risk, he remained anticoagulated with warfarin, although his international normalized ratio fluctuated considerably and was difficult to maintain within the therapeutic range.

Worsening Hypertension

During the first 6 months after presentation, and in the context of ongoing nephrotic syndrome and fluid overload, our patient’s BP rose rapidly to \(\approx 175/110\) mm Hg, on no medications. Over this time, he retained normal excretory renal function and serum electrolytes. Inflammatory markers were consistent with active SLE. Serum albumin was depressed at 17 g/L (1.7 g/dL), and he was hyperlipidemic (cholesterol 6.6 mmol/L and triglycerides 8.9 mmol/L), in keeping with nephrotic syndrome. Many factors were likely to have contributed to his hypertension, which would require different therapeutic strategies (Table S2).

Discussion: Managing the Hypertension

Dr Dhaun: Given the likely pathophysiology for our patient’s hypertension, would anyone like to suggest some management strategies?

Dr Oparil: Blockers of the renin–angiotensin–aldosterone system (RAAS).
Dr Dhaun: A good start! Would you like to give our patient an angiotensin-converting enzyme (ACE) inhibitor or an angiotensin receptor blocker?

Dr Oparil: I would probably start with an ACE inhibitor. Thirty years ago, that was used for lupus. And then if that did not work, I would probably add an endothelin blocker. I would not combine ACEs and angiotensin receptor blockers, at least at first.

Dr Dhaun: Okay, so we have the option of an ACE inhibitor followed by an endothelin blocker. Endothelin blockers are only currently licensed for pulmonary arterial hypertension and scleroderma ulceration, so we would be using them off-license. Any other suggestions of how we manage this patient’s hypertension—any nonpharmacological strategy?

Dr Batlle: We talk a lot about the RAAS, but rarely try to measure its activity. You could start by measuring plasma renin activity, which is significantly elevated in a scleroderma renal crisis, for instance. We learned from one of the presentations yesterday that urinary angiotensinogen, which is easily measurable, can be decreased by mycophenolate. So you could potentially measure urine angiotensinogen and circulating angiotensin II.

Dr Dhaun: Absolutely. One thing I would like to draw your attention to is that this case is from some years ago.

Urinary angiotensinogen would not have been available to us then, nor is it, to my knowledge, used in the clinical setting. Certainly, plasma renin and plasma/urine catecholamines might have been available. I am not sure how interpretable these would be in the context of renal impairment, proteinuria, fluid overload, and the combination of various therapies such as corticosteroids and other immunosuppressive agents.

Dr Elijovich: Given the level of BP, most guidelines would support the use of 2 different antihypertensive agents. I would consider ACE inhibitors, dihydropyridine calcium channel blockers, and a diuretic as the main options here. However, I am unclear as to the benefits of calcium channel blockers in those with kidney impairment.

Dr Dhaun: Sir, before you sit down may I ask you, which class of calcium channel blockers you would choose? The ones whose hemodynamic effects are predominantly on the afferent renal arterioles such as nifedipine, or those that predominantly affect the efferent renal arterioles such as amlodipine?
Dr Elijovich: I was surprised recently by the fact that impairment of renal autoregulation is applicable to both dihydropyridine and nondihydropyridine calcium channel blockers. The effect of nondihydropyridines is similar in direction but less powerful than that of dihydropyridines, consistent with the less potent vasodilator effects of the nondihydropyridine agents.

Dr Dhaun: Fair enough. So I am going to take the opportunity to ask you another question. What would you be trying to achieve here by controlling BP in this patient? What is your target and what are your goals longer term?

Dr Elijovich: My main concern is the contribution of his high BP to the progression of renal disease.

Progress

As discussed, management of this patient’s BP required a multi-faceted approach. Most importantly, we had still not managed to achieve remission of his SLE. General lifestyle measures were encouraged, namely salt and fluid restriction. Pharmacologically, a combination of diuretics and RAAS blockade was initiated—furosemide 80 mg daily and valsartan 160 mg daily; he was intolerant of ramipril because of headaches. Given the lack of BP improvement, 2 further agents, a calcium channel blocker and an α-blocker, were added. However, these provided little added benefit—average BP remained ≈170/90 mm Hg (Figure 3).

Our aims here were to reduce our patient’s proteinuria (and so preserve renal function) and lowering his cardiovascular risk. This risk is disproportionately high in SLE with up to 50-fold increased risk of myocardial infarction.4,5 Given his renal impairment and genetic background, his cardiovascular risk was likely to be significant, even at this young age.

At this point, our patient continued to have 5 to 10 g/d of proteinuria with deteriorating renal function. Thus, achieving BP control was critical. He was also anemic (hemoglobin 84 g/L), in keeping with his level of renal dysfunction and hyperkalemic (K+ 5.8 mmol/L). Continued lymphopenia, hypocomplementemia, and prolonged erythrocyte sedimentation rate were all consistent with an ongoing active SLE.

Dr Dhaun: So our patient’s BP and renal function are deteriorating. What factors might be contributing?

Professor Dominicczak: One problem is that you have not managed to control his lupus. He still has an active immune disease that is destroying his kidneys, whatever you do. And even if his BP had been perfect, which is unlikely under the circumstances, you would still have progression of the disease because the kidneys are being destroyed.

Dr Dhaun: Absolutely. As Professor Dominicczak correctly points out, the active SLE will not only be driving the renal disease but as it is a systemic disease, it will also be contributing to the hypertension directly. So one mechanism to reduce the BP has to be targeting the underlying SLE. However, the SLE treatment will also be contributing to the hypertension, as our patient continues on reasonably high doses of corticosteroids alongside other immunosuppression.

Dr Basile: Can you go back to the drugs again? Okay, so od means once a day?

Dr Dhaun: Yes, od means once daily.

Dr Basile: What was the potassium?

Dr Miller-Hodges: 5.8 mmol/L

Dr Basile: I appreciate that the K+ is a concern and I do not know if you have access to the new drugs available to manage hyperkalemia. However, using once daily furosemide in the management of hypertension is a big mistake in my opinion as this will lead to paroxysmal sodium retention. If you are going to use furosemide I would suggest at least a twice daily dosing regimen.

Valsartan 160 mg once a day also concerns me. It is as if there is a fire going on in your house, and you are trying to use a straw to try to put the fire out, while the fire is still raging. The patient’s BP is elevated. If the patient is on mycophenolate why not use diltiazem to reduce its dose and thus save some money with the added benefit of better BP control.

The biggest problem I see with diltiazem is underdosing; with verapamil, it is the constipation. Using an inadequate dose is common; diltiazem is available in 180, 240 and 300 mg tablets, and you need a good-sized dose for it to be effective as a BP-lowering agent.

And then as a fourth drug, I am not sure why you would use an α-blocker before a β/α-blocker. I know the K+ is a concern, and that might be a reason to use a lower dose of the

Figure 3. Blood pressure (BP) and antihypertensive agents. MR indicates modified release.
valsartan but would you consider spironolactone? I think this patient has a lot of salt-/volume-induced hypertension.

Finally, do we have any idea of nighttime BP? Would you consider giving some of these medicines at night instead of just in the morning to achieve better 24-hour BP control? In general, I would have approached BP control differently.

Dr Dhaun: Thank you, those are all excellent points. Broadly in response, this patient was managed in the nephrology unit, and so we often tend to focus on the kidney and the SLE before BP. For example, our patient is nephrotic, and so the valsartan is an attempt to reduce proteinuria. The rationale for the once daily furosemide will become apparent later. However, this was more directed toward managing fluid overload than the hypertension. Finally, there will be a US/European divide here; we tend not to use diltiazem for hypertension. We tend to use α-blockers as third- or fourth-line agents for the treatment of hypertension.

Hypertension in Nephrotic Syndrome

Thus, the major factors contributing to his hypertension were worsening renal impairment, ongoing proteinuria, salt and water retention, and ongoing SLE disease activity. We also had some concerns about adherence to treatment, suggested by his erratic warfarin control, although this was never confirmed.

There are 2 main theories for the cause of hypertension in nephrotic syndrome. The underfill hypothesis suggests that the significant loss of proteins in the urine leads to a fall in plasma oncotic pressure which leads to extracellular volume expansion and resultant intravascular volume depletion. This then promotes salt and water retention via the activation of the RAAS. By contrast, the overfill hypothesis advocates that the urinary protein loss itself causes proteolytic activation of the epithelial sodium channel, directly leading to renal sodium retention. Plasminogen is lost in the urine and is activated to plasmin in the urinary space by the urokinase-type plasminogen activator. This is thought to directly and indirectly activate epithelial sodium channel.

Both these mechanisms may be active in this case.

Further Investigations and Progress

Our patient had little evidence of hypertensive end-organ damage outside the kidney. He had a normal transthoracic ECHO and normal fundoscopy. Twenty-four–hour ambulatory BP measurements were not available to us. Dual RAAS blockade was attempted with the reintroduction of ramipril, but this had to be withdrawn because of hyperkalemia, even with correction of his acidosis. The diuretic dose was then increased. A repeat renal biopsy was performed to clarify the extent of lupus nephritis and to exclude additional causes. This showed progression of his underlying disease (Figure S1).

In an attempt to control our patient’s SLE, we opted for a further trial of oral (low dose) cyclophosphamide but without the mesna component. By this point, he was experiencing the burden of heavy immunosuppression and had had several hospital admissions with infections. His renal function continued to deteriorate, and he was now unable to tolerate any form of RAAS blockade because of hyperkalemia. He was maintained on a combination of loop and thiazide diuretics, a calcium channel blocker and an α-blocker.

Use of spironolactone in this gentleman, as was previously suggested, would have been difficult. He had deteriorating renal function and a tendency toward hyperkalemia even on suboptimal doses of valsartan. From a nephrology perspective, spironolactone was best avoided, particularly given a significant dietary K+ intake.

The disease progression evident on the repeat renal biopsy suggested that there was compromised renal blood flow. Therefore, we felt that a major component of our patient’s hypertension was driven by the renal inflammation, so the focus of the management should be on controlling his underlying SLE.

Discussion: Additional Therapies?

Dr Dhaun: So, what would you do next in this gentleman?

Dr Batlle: I like this comment about plasmin activating the sodium channel; this is a novel concept. In the nephrotic syndrome, independent of proximal nephron sites that retain sodium, a site of sodium retention is the cortical collecting duct where plasmin might activate epithelial sodium channel. So focusing on downregulating this with either spironolactone or amiloride may work for hypertension control. However, as a consequence, you might worsen the hyperkalemia. This is a situation where the new potassium binders might aid us. We have patiromer, which is already approved in the United States, and Z-S9 is pending Food and Drug Administration approval. Either these 2, or even the old-fashion kayesalate, could be used to facilitate the treatment of hyperkalemia. I also could not agree more with the comment that once daily furosemide is not appropriate but common practice in the United States. I see that sadly this also happens in the United Kingdom.

Dr Dhaun: Thank you. Unfortunately, the potassium binders were not available to us at that time or indeed now. Our general maneuver to offset the potassium retention associated with RAAS blockade was to add a loop or thiazide diuretic to increase kaliuresis. So, what would you do next in this patient?

Dr Elijovich: I am going to suggest something else thinking more of a few steps further down the road. Although SLE is primarily an antibody-mediated disease, you cannot really exclude a participation of T-cell–mediated inflammation. This might be contributing to the hypertension. Then if I would have failed with more therapies in this patient and even at the risk of going to jail…

Dr Dhaun: Are you hinting at renal nerve ablation here?

Dr Elijovich: Not at all! For renal nerve ablation, we have the clearly negative results of a randomized clinical trial. I will not go to jail for that. But I would go to jail for abatacept; this would inhibit the costimulation of T cells. I do not know what it would do to the lupus because you have a very active process in terms of autoantibodies, but it might well reduce the BP. Who knows?

Dr Dhaun: Yes, abatacept is an interesting idea. The trials of abatacept in renal disease and hypertension were not there at the time this patient was being managed. However, I would come back to you and suggest that while there is indeed a T-cell component to SLE, it is primarily driven by B cells and plasma cells so perhaps a B-cell depletion strategy or an
A pril 2017

inhibitor of B-cell–activating factor might be more appropri-
ate here. So, any other ideas?

Dr Basile: What was his heart rate?

Dr Dhaun: Ah, good question.

Dr Miller-Hodges: 90 bpm.

Dr Basile: A lot of the drugs you are currently using to
to control BP work on volume, and to me you have little effec-
tive blockade of the RAAS. I think we must work on that. If I
could not because of the potassium, which is really tying my
hands, it would be nice if you had patiromer available.

Dr Dhaun: Sadly we do not.

Dr Basile: Okay. I would at least want to use a β-/α-blocker
if you feel strongly about the α-blocker. Or even a β-blocker
alone. I would also consider, because of the renal function,
another loop diuretic. I do not know how badly the renal func-
tion or the GFR is now. I would consider adding diltiazem to
the nifedipine. Is that a once-a-day, long-acting nifedipine?

Dr Dhaun: That is correct.

Dr Basile: In these kinds of complicated cases, adding dil-
tiazem to the dihydropyridine calcium channel blocker can get
you some additional BP reduction. Of note, the higher the salt
intake, the more these agents will lower BP as they work on
volume as one of the mechanisms of action. One of the rea-
sons why we do not have varaparetic (verapamil+diuretic) or
diltiazaretic (diltiazem+diuretic) is because when those stud-
ies were done, sodium was not controlled for. So it was hard
to see an additional effect of those 2 agents together unless
sodium was controlled for.

Dr Dhaun: Two comments in passing. We attempted the
addition of the direct renin inhibitor, aliskiren, to valsartan.
However, this had to be stopped due to unacceptable hyper-
kalemia. Second, we also tried short-acting nifedipine given
3× a day. Although this provided a better BP-lowering effect
than the longer acting drug, it resulted in severe headaches so
had to be stopped.

Acute Deterioration

With limited therapeutic options, the patient’s BP remained
high. Soon afterward he presented acutely to the Accident and
Emergency Department with headaches, seizures, confusion,
and agitation. He was very unwell. BP was 240/140 mm Hg,
pulse 157 bpm, temperature 36.6°C (97.8°F), and blood glu-
cose 10.2 mmol/L (184 mg/dL). He was intubated and ven-
tilated, and his seizures were controlled with intravenous
phenytoin. Investigations at this time are shown in Table S1B.
He was still anemic; his C-reactive protein was now high, and
he had stable renal impairment. Serum electrolytes were nor-
mal; there was systemic lactic acidosis in keeping with sus-
tained seizure activity.

Dr Dhaun: So what is the differential diagnosis here?

Dr Laffer: You basically are questioning whether he has
lupus encephalopathy versus what we used to call hyperten-
sive encephalopathy, or now posterior reversible encephalopa-
thy syndrome (PRES).

Dr Dhaun: Correct! Another possibility is that this could
be a complication of his lupus, particularly infection second-
ary to his immunosuppression, or as you suggest a complica-
tion of the hypertension such as a stroke.

Dr Miller-Hodges: Our key message is that, given the sig-
nificant immunosuppressive burden, infection is an important
differential here. Given the acute change in neurological state,
we should attempt to discriminate between this being a pri-
arily vascular event or a primarily autoimmune event. How
might we do that?

Audience Member: You need a magnetic resonance imag-
ing brain scan.

Dr Miller-Hodges: Anything else?

Dr Dhaun: Yes, I have just got to say, we are in the United
Kingdom, not the United States.

Professor Jennings: You might look at his retina.

Professor Dominiczak: Look at his retina and if okay, do
lumbar puncture maybe?

Dr Dhaun: These are our choices in the United Kingdom.

Professor Dominiczak: Yes, a graded approach to
investigation.

Dr Miller-Hodges: He was neurologically altered with a
Glascow Coma Scale score of 11.

Audience Member: So back in the old days, if you did not
have papilledema, one might want to do a lumbar puncture.

Figure 4. Brain imaging. A, Noncontrast computed tomography brain, showing areas of low attenuation in the posterior occipital regions. B, Magnetic resonance imaging brain scan, showing areas of hyperintense white matter changes in the posterior occipital regions.
Investigations and Progress

In the United Kingdom, the first imaging performed was a computed tomography head. The initial noncontrast scan showed some areas of low attenuation in the posterior occipital regions and excluded a major bleed or space-occupying lesion (Figure 4A). A lumbar puncture was performed, and the cerebrospinal fluid was acellular and had glucose and protein levels within normal limits. All microbiology and virology was negative. A subsequent magnetic resonance imaging brain scan demonstrated areas of hyperintense white matter changes in the posterior occipital regions (Figure 4B). The working diagnosis was PRES so the clinical priority was BP control.

Dr Dhaun: Now, the question here is how are you going to reduce the BP acutely? Again, there might be a UK/US divide here.

Dr Basile: To me, when the brain is involved in an encephalopathic presentation, nitroprusside is the first drug to consider.

Dr Dhaun: Okay, so sodium nitroprusside. Anything else? Professor Dominiczak: Nitrates?

Dr Dhaun: Yes, intravenous nitrates. Any other class of antihypertensive agent that you might use?

Professor Dominiczak: Some people also use intravenous labetalol.

Professor Luft: Perhaps even earlier in this course, we used to give people minoxidil, and their renal function occasionally got substantially better. I realize it might cause fluid retention but particularly if you are only giving furosemide 80 mg once a day but that might be an option.

Dr Dhaun: Thank you. I think minoxidil is used more in the United States than in the United Kingdom? We rarely use it.

Dr Elijovich: I wanted to remind you that the improvement in GFR with minoxidil is like the early improvement in GFR with amiodipine in AASK. In the amiodipine arm of AASK, the GFR initially goes up, and I believe you, as nephrologists, should not like it.

Dr Dhaun: Thank you for that. Okay, so intravenous nitrates and β-blockers are both options here. Could I ask how much you would want to reduce the BP by?

Professor Jennings: We want to go to safe levels, not normal levels.

Professor Dominiczak: And slowly, not too fast.

Acute Management

An acute reduction in BP was attempted using intravenous glyceryl trinitrate (titrated to 250 mcg/min). Nitroprusside was contraindicated because of the presence of significant renal impairment and thus increased risk of toxicity. We aimed for a target BP reduction of ≈10% to 20% within the first hour and <25% within the first 24 hours to avoid precipitating further vascular injury via cerebral hyperperfusion.

BP fell by ≈20% over the first 24 hours using intravenous nitrates, and our patient’s consciousness level improved, although he remained confused. However, despite the addition of his usual and additional oral antihypertensive agents (metoprolol 100 mg twice daily [bd], ramipril 10 mg od, metolazone 2.5 mg od, doxazosin 8 mg bd, nifedipine 20 mg three times daily, and candesartan 8 mg bd), as well as intravenous furosemide (120 mg bd) and intravenous adrenergic blockade (labetalol 2 mg/min), his BP remained ≈200/100 mm Hg without a return to normal neurological function (Figure 5A). His renal function deteriorated (creatinine 205 μmol/L (2.32 mg/dL), and he had now developed both hyponatremia (Na+ 132 mmol/L [normal range 135–145]) and hypokalemia (3.0 mmol/L [normal 3.6–5.0]).

Discussion: Next Steps

To summarize, despite α blockade, β blockade, calcium channel blockade, RAAS blockade, and addition of both loop and thiazide diuretics, our patient’s BP remains dangerously high.

What further information would you like here and what would you do next?

Dr Laffer: In terms of blood–brain barrier and SIADH (syndrome of inappropriate antidiuretic hormone), that is now going to be a problem as well (ie, cyclophosphamide may be directly contributing).
Figure 5. Blood pressure (BP) and proteinuria during acute presentation with seizures and during recovery. A, BP and treatment during acute phase. B, BP and treatment during recovery. C, Proteinuria during recovery (g/24 h). bd indicates twice daily; GTN, glyceryl trinitrate; MMF, mycophenolate mofetil; NG, nasogastric; od, once daily; and tds, three times daily.
Dr Miller-Hodges: Yes, indeed it is, thank you. Would anyone else like to suggest anything?

Dr Basile: I would like to get a handle on his volume status. You have him on dual RAAS blockade. His renal function has deteriorated from 1.9 to 2.32, while all of this is going on. Would a plasma renin and a plasma aldosterone help in any way, or a noninvasive evaluation of cardiac output and peripheral vascular resistance, just to get a better handle on his volume status as it is often difficult to determine by clinical examination. I presume the urine output is good?

Dr Miller-Hodges: Urine output was adequate rather than good.

Dr Basile: So, you need to know which way to go when adding additional antihypertensive agents. I also remain concerned that he is on ramipril and valsartan (dual RAAS blockade) with renal deterioration at this point.

Dr Dhaun: May I make a couple of comments at this point. At presentation, our patient had evidence of an acute fall in hemoglobin level. This was on a background of uncontrolled hypertension. While Dr Laragh was a proponent of using the plasma renin as a deciding factor for the first drug chosen, we found it best in those cases where we were now in a position to aggressively offload his salt and water excess using an aldosterone antagonist (spironolactone). While it may be difficult to interpret these levels in the setting of RAAS blockade and fluid overload. Urinary catecholamines were not checked given the confounding effect of dual RAAS blockade and fluid overload. Urinary catecholamines were normal, and a magnetic resonance imaging scan of his abdomen showed no adrenal masses and excluded renal artery stenosis.

Thank you for the suggestions. Renin and aldosterone levels were not checked given the confounding effect of dual RAAS blockade and fluid overload. Urinary catecholamines were normal, and a magnetic resonance imaging scan of his abdomen showed no adrenal masses and excluded renal artery stenosis.

With no evidence of infection, the posterior white matter changes evident on imaging, and neurological findings that corresponded to the BP, we felt the diagnosis remained consistent with PRES. However, our patient’s BP was unusually difficult to manage, and he had ongoing evidence of active SLE. Both needed to be addressed. As has been suggested, we were now in a position to aggressively offload his salt and water excess using an aldosterone antagonist (spironolactone 100 mg daily).

The SLE was treated with high-dose prednisone (40 mg daily), plasmapheresis, and full-dose mycophenolate mofetil. His BP improved rapidly, in the context of an 8 L diuresis. He was discharged from hospital 2 weeks later with normal a neurological examination but still requiring multiple antihypertensive agents (Figure 5A). This requirement was transient, as his SLE rapidly went into remission over the next 6 weeks. He had complete resolution of his nephrotic syndrome, with urinary proteinuria falling to <0.5 g/d and stabilization of renal function (Figure 5B and 5C). Immunologic markers of SLE activity also improved.

He was maintained on long-term dual RAAS blockade, a β-blocker, and twice daily furosemide, with a clinic BP of

### Table. Risk Factors for Posterior Reversible Encephalopathy Syndrome in Systemic Lupus Erythematosus

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Mechanism</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immune complex-mediated endothelial damage</td>
<td>Endothelial dysfunction</td>
<td>Compromise integrity of blood–brain barrier</td>
</tr>
<tr>
<td>Endothelin-1 activation</td>
<td>Endothelial dysfunction</td>
<td>Compromise cerebrovascular autoregulatory mechanisms</td>
</tr>
<tr>
<td>RAAS activation</td>
<td>Compromise cerebrovascular autoregulatory mechanisms</td>
<td></td>
</tr>
<tr>
<td>Proinflammatory cytokines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cytotoxic drugs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal impairment</td>
<td>Endothelial dysfunction</td>
<td>Compromise cerebrovascular autoregulatory mechanisms</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Cerebral hypertension</td>
<td></td>
</tr>
<tr>
<td>Fluid retention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young age</td>
<td>Associations</td>
<td></td>
</tr>
<tr>
<td>Lymphopenia</td>
<td>(mechanism unknown)</td>
<td></td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RAAS indicates renin–angiotensin–aldosterone system.

### Case Resolution

Thank you for the suggestions. Renin and aldosterone levels were not checked given the confounding effect of dual RAAS blockade and fluid overload. Urinary catecholamines were normal, and a magnetic resonance imaging scan of his abdomen showed no adrenal masses and excluded renal artery stenosis.

With no evidence of infection, the posterior white matter changes evident on imaging, and neurological findings that corresponded to the BP, we felt the diagnosis remained consistent with PRES. However, our patient’s BP was unusually difficult to manage, and he had ongoing evidence of active SLE. Both needed to be addressed. As has been suggested, we were now in a position to aggressively offload his salt and water excess using an aldosterone antagonist (spironolactone 100 mg daily).

The SLE was treated with high-dose prednisone (40 mg daily), plasmapheresis, and full-dose mycophenolate mofetil. His BP improved rapidly, in the context of an 8 L diuresis. He was discharged from hospital 2 weeks later with normal a neurological examination but still requiring multiple antihypertensive agents (Figure 5A). This requirement was transient, as his SLE rapidly went into remission over the next 6 weeks. He had complete resolution of his nephrotic syndrome, with proteinuria falling to <0.5 g/d and stabilization of renal function (Figure 5B and 5C). Immunologic markers of SLE activity also improved.

He was maintained on long-term dual RAAS blockade, a β-blocker, and twice daily furosemide, with a clinic BP of
135/75 mm Hg. A repeat magnetic resonance imaging scan at 6 months showed complete resolution of the previous changes.

**PRES in SLE**

PRES describes a clinical neurological syndrome characterized by headache, seizures, altered mental status, and typical radiological findings (white matter edema particularly affecting the posterior circulation). It is thought to arise from a failure of cerebral autoregulation in the context of an abrupt rise in BP. This leads to hyperperfusion and vasogenic edema. Patients with SLE are at increased risk of developing PRES because of many mechanisms outlined in the Table.

**Summary**

We present a case of hypertension and a hypertensive emergency in the context of active SLE. BP control was achieved with diuresis, RAAS blockade, and aldosterone antagonist, as well as by aggressive management of the underlying SLE.

**Sources of Funding**

N. Dhaun is supported by a British Heart Foundation Intermediate Clinical Research Fellowship (FS/13/30/29994). This work was supported by IMIM (Hospital del Mar Medical Research Institute) and Spanish Research Network REDINREN (RD16/0009/0013).

**Disclosures**

None.

**References**


Hypertension and Its Complications in a Young Man With Autoimmune Disease
Eve Miller-Hodges, Anna F. Dominiczak, Garry L.R. Jennings, Suzanne Oparil, Daniel C. Batlle, Fernando Elijovich, Jan N. Basile, Cheryl L. Laffer, Anna Oliveras and Neeraj Dhaun

*Hypertension*. 2017;69:536-544; originally published online February 27, 2017; doi: 10.1161/HYPERTENSIONAHA.117.09036

*Hypertension* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2017 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://hyper.ahajournals.org/content/69/4/536

Data Supplement (unedited) at:
http://hyper.ahajournals.org/content/suppl/2017/03/02/HYPERTENSIONAHA.117.09036.DC2
http://hyper.ahajournals.org/content/suppl/2017/02/27/HYPERTENSIONAHA.117.09036.DC1

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Hypertension* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Hypertension* is online at:
http://hyper.ahajournals.org//subscriptions/
Supplement

Hypertension and its complications in a young man with autoimmune disease

Eve Miller-Hodges,¹ Anna F. Dominiczak,² Garry L.R. Jennings,³ Suzanne Oparil,⁴ Daniel C. Batlle,⁵ Fernando Elijovich,⁶ Jan N. Basile,⁷ Cheryl L. Laffer,⁸ Friedrich C. Luft,⁹ Anna Oliveras,¹⁰ Neeraj Dhaun¹

¹ University/British Heart Foundation Centre of Research Excellence, University of Edinburgh, UK

² Institute of Cardiovascular and Medical Sciences, College of Medical, Veterinary and Life Sciences, University of Glasgow, UK

³ Baker IDI Heart and Diabetes Institute, Melbourne, Australia

⁴ Department of Medicine, Division of Cardiovascular Disease, University of Alabama at Birmingham, Birmingham, AL, USA

⁵ Division of Nephrology and Hypertension, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

⁶ Division of Clinical Pharmacology, Department of Medicine, Vanderbilt University Medical Center, Nashville TN, USA

⁷ Medical University of South Carolina, Charleston, SC, USA

⁸ Department of Medicine, Vanderbilt University School of Medicine, Nashville TN, USA

⁹ Experimental and Clinical Research Center, a cooperation between the Max Delbrück Center for Molecular Medicine in the Helmholtz Association and the Charité Universitätsmedizin Berlin, Berlin, Germany

¹⁰ Hypertension Unit, Nephrology Department, Hospital Universitari del Mar, Barcelona, Spain. IMIM (Hospital del Mar Medical Research Institute), Spanish Research Network REDINREN (RD16/0009/0013)
The following case was presented 16 September 2016 as part of the Clinical-Pathological conference chaired by Anna F. Dominiczak and Garry L.R. Jennings at the Council on Hypertension 2016 Scientific Sessions. Eve Miller-Hodges presented the case and the discussion was led by Neeraj Dhaun.
Table S1: Investigations. Abnormal results indicated by *

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Reference Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Initial Investigations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creatinine, mg/dL</td>
<td>0.80</td>
<td>(0.67 - 1.36)</td>
</tr>
<tr>
<td>Creatinine, μmol/L</td>
<td>69</td>
<td>(60-120)</td>
</tr>
<tr>
<td>Albumin, g/L</td>
<td>25*</td>
<td>(35 - 50)</td>
</tr>
<tr>
<td>Urinary analysis</td>
<td>Blood**, protein****</td>
<td></td>
</tr>
<tr>
<td>Urinary protein, g/24hours</td>
<td>3.90*</td>
<td>(&lt;100mg)</td>
</tr>
<tr>
<td>C3, g/L</td>
<td>0.49*</td>
<td>(0.75 - 1.65)</td>
</tr>
<tr>
<td>C4, g/L</td>
<td>0.09*</td>
<td>(0.14 - 0.54)</td>
</tr>
<tr>
<td>Anti dsDNA, U/L</td>
<td>&gt;200*</td>
<td>(0 - 10)</td>
</tr>
<tr>
<td>Anti Ro, U/L</td>
<td>&gt;100*</td>
<td>(0 - 25)</td>
</tr>
<tr>
<td>Anti La, U/L</td>
<td>&gt;100*</td>
<td>(0 - 25)</td>
</tr>
<tr>
<td>Anticardiolipin IgG, GPLU/ml</td>
<td>4</td>
<td>(0 - 10)</td>
</tr>
<tr>
<td>Anticardiolipin IgM, MPL</td>
<td>1.50</td>
<td>(0 - 9.8)</td>
</tr>
<tr>
<td>Lupus anticoagulant</td>
<td>Negative</td>
<td></td>
</tr>
<tr>
<td>Platelets, x 10^9/L</td>
<td>284</td>
<td>(150 - 350)</td>
</tr>
<tr>
<td>Lymphocytes, x 10^9/L</td>
<td>0.48*</td>
<td>(1.5 - 4.0)</td>
</tr>
<tr>
<td>CRP, mg/L</td>
<td>13</td>
<td>(1 - 5)</td>
</tr>
<tr>
<td>ESR, mm/hr</td>
<td>102*</td>
<td>(0 - 10)</td>
</tr>
<tr>
<td>Cholesterol, mmol/L</td>
<td>6.6*</td>
<td></td>
</tr>
<tr>
<td>Urate, mmol/L</td>
<td>0.28</td>
<td>(0.12 - 0.36)</td>
</tr>
<tr>
<td>Echocardiogram</td>
<td>Normal LV size</td>
<td>Good systolic function</td>
</tr>
<tr>
<td>Fundoscopy</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td><strong>B Investigations at acute presentation with seizures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemoglobin, g/L</td>
<td>79*</td>
<td>(135 - 180)</td>
</tr>
<tr>
<td>WCC, x 10^9 /L</td>
<td>9.6</td>
<td>(4.0 - 11.0)</td>
</tr>
<tr>
<td>Platelets, x 10^9 /L</td>
<td>261</td>
<td>(150 - 450)</td>
</tr>
<tr>
<td>CRP, mg/L</td>
<td>139*</td>
<td>(0 - 5)</td>
</tr>
<tr>
<td>BUN, mg/dL</td>
<td>35.9*</td>
<td>(7 - 18.5)</td>
</tr>
<tr>
<td>Urea, mmol/L</td>
<td>12.8*</td>
<td>(2.5 - 6.6)</td>
</tr>
<tr>
<td>Creatinine, mg/dL</td>
<td>1.98*</td>
<td>(0.67 - 1.36)</td>
</tr>
<tr>
<td>Creatinine, μmol/L</td>
<td>175*</td>
<td>(60 - 120)</td>
</tr>
<tr>
<td>Sodium, mM</td>
<td>132*</td>
<td>(135 - 145)</td>
</tr>
<tr>
<td>Potassium, mM</td>
<td>4.4</td>
<td>(3.6 - 5.0)</td>
</tr>
<tr>
<td>H+, nM</td>
<td>81.3*</td>
<td>(35 - 45)</td>
</tr>
<tr>
<td>Lactate, mM</td>
<td>12.0*</td>
<td>(0.5 - 2.2)</td>
</tr>
<tr>
<td>Urinary metanephrine, μmol/24hr</td>
<td>1.3</td>
<td>(0.4 - 3.4)</td>
</tr>
<tr>
<td>Urinary normetanephrine, μmol/24hr</td>
<td>0.5</td>
<td>(0.3 - 1.7)</td>
</tr>
</tbody>
</table>
Table S2: Factors contributing to hypertension

<table>
<thead>
<tr>
<th>Traditional Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Race</td>
</tr>
<tr>
<td>• Renal disease</td>
</tr>
<tr>
<td>• Dietary salt intake</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lupus-related / specific risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Systemic inflammation</td>
</tr>
<tr>
<td>• Glucocorticoids</td>
</tr>
<tr>
<td>• Nephrotic syndrome</td>
</tr>
<tr>
<td>• Endothelial dysfunction:</td>
</tr>
<tr>
<td>• Immune-complex mediated endothelial damage</td>
</tr>
<tr>
<td>• Endothelin-1 activation</td>
</tr>
<tr>
<td>• Renin-angiotensin-aldosterone system (RAAS) activation</td>
</tr>
</tbody>
</table>

Figure S1: Later glomerular histology  
Biopsy 2: Class IV (proliferative) & Class V (membranous) lupus nephritis. Single arrow: gross thickening of the capillary basement membranes; double arrow: proliferation throughout the glomerulus