Ms. Lake

Ms. Lake was created with a renin secreting tumor (1000 GU/Min vs. 290 normally). Table salt was kicked up to 260 mEq/Day from a normal of 180.

Ms. Lake is healthy but has headaches.

Load Ms. Lake (MS_LAKE.ICS) using the **File / Load Initial Conditions** main menu selection.

Is Ms. Lake OK? In her thumbnail sketch on the Charts panel, she complains of headaches, but that is not very informative.

Check Ms. Lake's blood pressure, heart rate, temperature and respiration using the Monitor panel.

Normal values were taken from Norm Subject.

Variable	Ms. Lake	N. Subject	Units

Blood Pressure		120 / 81	mmHg
Heart Rate		73	Beats / Min
Temperature		98.8	degree F
Respiration Rate		12	Breaths / Min

Ms. Lake is presenting with a fairly high blood pressure.

Blood Chemistry

Its time for some blood chemistry. Go to the Blood And Urine Samples panel. Get venous blood gases. Click Take Sample Now in the Venous Blood Gases box. Is there evidence of an acid/base disturbance?

Variable	**Ms. Lake**	**N. Subject**	**Units**
pCO2		42	mmHg
pH		7.40	pH Units
[H+]		40	pMol/L
[HCO3-]		28	mEq/L

Check blood electrolytes. Click Take Sample Now in the Venous Blood Sample box. Are the blood electrolytes normal?

Variable	Ms. Lake	N. Subject	Units
[Na+]		145	mEq/L
[K+]		4.4	mEq/L
[Cl-]		108	mEq/L
[BUN]		13	mG/dL
[Protein]		6.9	G/dL
Osmolarity		292	mOsm/L
Hematocrit		44	%

The plasma [K+] value is a bit worrisome. We may return to this matter later.

Invasive Studies

Use the **View / Basic Physiology** and **Nephron Details** main menu selections to install the basic physiology and nephron toolbar buttons.

Several clinical studies indicate that most patients with hypertension present with elevated arterial pressure and elevated vascular resistance but normal cardiac output.

Go to Pressure and record mean arterial pressure. Then go to Flow and record cardiac output. Finally, go to Conductance and record total peripheral resistance.

Variable	Ms. Lake	N. Subject	Units
Mean Arterial Pressure		97	mmHg
Cardiac Output		5360	mL/Min
Peripheral Resistance		0.018	mmHg/ (mL/Min)

What are the percent changes in pressure, flow and resistance?

Pressure change is _____ %.

Cardiac output change is _____ %.

Peripheral resistance change is _____ %.

Ms. Lake seems pretty typical.

Sodium Balance

We may learn something from Ms. Lake's sodium balance. Go to the Diet panel and note Ms. Lake's daily sodium intake. Then go to the Urine panel and note Ms. Lake's

rate of Na+ excretion.

Na+ _____ mEq/Min x 1440 = _____ mEq/Day

Variable	Ms. Lake	N. Subject	Units
Na+ Intake		180	mEq/Day
Na+ Output		180	mEq/Day

Two questions must be answered.

- Is Ms. Lake in sodium balance?
- Is Ms. Lake on a high, normal or low sodium diet?

Increased extracellular Na+ mass may be contributing to Ms. Lake's hypertension. Go to Na+ and note the Na+ mass.

Variable	Ms. Lake	N. Subject	Units
ECFV Na+ Mass		2150	mEq

What is a reasonable diagnosis at this point?

Hormones In The Blood

An examination of some blood hormones may be beneficial. Go to Blood Chemistry and examine the relevant concentrations.

Variable	Ms. Lake	N. Subject	Units
[AII]		20	mEq/Day
Renin		2.0	GU
[Aldo]		330	pMol/L
[ADH]		2.0	pG/mL
[ANP]		20	pMol/L

Considering that Ms. Lake is taking a fairly salt rich diet, her concentrations for renin and angiotensin are very, very high.

What is a reasonable diagnosis now?

Renin vs. Salt

A decreased salt intake stimulates renal renin secretion. This increases plasma renin and angiotensin levels. Increased angiotensin decreases renal blood flow and increases sodium reabsorption, helping to conserve sodium and maintain sodium balance. Increased angiotensin also produces peripheral vasoconstriction which helps to maintain arterial pressure.

An increased sodium intake inhibits renin secretion which promotes renal sodium excretion and peripheral vasodilation.

This reciprocal relationship between sodium intake and renin is plotted below for Norm Subject. It is roughly a hyperbola.

Plot Ms. Lake's data on this graph.

Thus, Ms. Lake's plasma renin activity is inappropriately high for the amount of sodium in her diet.

Therapy

To lower Ms. Lake's blood pressure, we might consider decreased sodium intake, blocking the formation of angiotensin or both.

First, lowered sodium intake. Go to Diet and slide table salt down to 40 mMol/Day. Go to Monitor to monitor blood pressure changes. Advance the solution 1 week.

Variable	Day 1	Day 8	Units
Blood Pressure			mmHg

In addition to blood pressure, check on changes in plasma renin activity, plasma angiotensin concentration and extracellular sodium mass.

It appears that decreased sodium intake decreased extracellular sodium mass while also stimulating more renin secretion. The net result was little change in blood pressure. Note the narrowing of pulse pressure. What caused that?

Next we'll block angiotensin formation. Click **Restart** to reestablish Ms. Lake's initial conditions. Then go to Blockers and slide AII converting enzyme inhibition up to 70%. Again, go to Monitor to monitor blood pressure changes. Advance the solution 1 week.

Variable	Day 1	Day 8	Units
Blood Pressure			mmHg

In addition to blood pressure, check on changes in plasma renin activity, plasma angiotensin concentration and extracellular sodium mass. Note that we've now uncoupled plasma renin activity and angiotensin concentration.

Finally, we'll lower sodium intake and block angiotensin formation. Click **Restart** to reestablish Ms. Lake's initial conditions. Go to Diet and slide table salt down to 40 mMol/Day. Then go to Blockers and slide AII converting enzyme inhibition up to 70%. Again, go to Monitor to monitor blood pressure changes. Advance the solution 1 week.

Variable	Day 1	Day 8	Units
Blood Pressure			mmHg

This is more like it. Ms. Lake's hypertension is under pretty good (but not perfect) control. Isn't it? Check out the relevant variables and make a final assessment.

References

Might put a Laragh reference to renin vs. salt here.

Ms. Lake - Notes

Ms. Lake's thumbnail sketch notes that she claims to be in good health but gets too many headaches.

In fact, Ms. Lake has severe hypertension caused by a renin secreting tumor and elevated table salt intake.

Creating Ms. Lake

The renin secreting tumor is turned on and intake of table salt is increased. The new parameter values are:

"Renin Secretion, Tumor Secretion" = 1000.0

"Diet Goal, Table Salt (mMol/Day)" = 260.0

The units for tumor renin secretion are GU (Goldblatt Units)/Min. Tumor secretion is displayed at the bottom of the  Angiotensin panel.

Then the solution was advanced for 1 month (43200 minutes).

Ms. Lake is ready.

Recap

This is a case of high blood pressure with elevated total peripheral resistance.

The subject was in sodium balance on a moderately high sodium diet with extracellular sodium mass normal to slightly expanded. In such a setting, we would expect plasma renin and angiotensin concentrations to be significantly lower than normal.

But renin and angiotensin were markedly above normal.

Blocking angiotensin formation in combination with decreased sodium intake created a natriuresis and brought blood pressure down to close to normal.

Postscript

What was really wrong with Ms. Lake? Go to  Angiotensin and scroll to the bottom of the panel.

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Ms. Lake Wrap-up

Summary

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