Formally, we want the result
$$\text{if } 1/2 \text{ then } x'=\text{head} \text{ else } x'=\text{tail} \text{ fi}$$
The procedure apparently achieves slightly more:
$$\text{if } 1/2 \text{ then } x'=\text{head} \wedge y'=\text{tail} \text{ else } x'=\text{tail} \wedge y'=\text{head} \text{ fi}$$
which can be simplified to
$$(x'\neq y')/2$$
If we call that result $R$, then one understanding of the procedure is the program
$$R \equiv \text{if } p \text{ then } x:= \text{head} \text{ else } x:= \text{tail} \text{ fi}.$$  
  $R \equiv \text{if } p \text{ then } y:= \text{head} \text{ else } y:= \text{tail} \text{ fi}.$$  
  $R \equiv \text{if } x=y \text{ then } R \text{ else } \text{ok} \text{ fi}.$

Another understanding of the procedure is the program
$$R \equiv \text{if } p \text{ then } x:= \text{head} \text{ else } x:= \text{tail} \text{ fi}.$$  
  $S \equiv \text{if } p \text{ then } y:= \text{head} \text{ else } y:= \text{tail} \text{ fi}.$$  
  $S \equiv \text{if } x=y \text{ then } x:= y; S \text{ else } \text{ok} \text{ fi}.$

The informal description could reasonably be understood either way; it is ambiguous. If two people with different understandings of the informal description of the procedure ask each other whether it is clear and understood, they will each say yes, and a long argument about whether the procedure produces the desired result will ensue. In contrast to that, the programs are unambiguous. With them we don't need to argue; we just calculate.

Let me begin with the first one.
$$\text{if } p \text{ then } x:= \text{head} \text{ else } x:= \text{tail} \text{ fi}.$$  
  $\text{if } p \text{ then } y:= \text{head} \text{ else } y:= \text{tail} \text{ fi}.$  
  $\text{if } x=y \text{ then } R \text{ else } \text{ok} \text{ fi}.$

$$\equiv \sum x'', y'': (p(x''=\text{head}) + (1-p)(x''=\text{tail})) \times (p(y''=\text{head}) + (1-p)(y''=\text{tail})) \times ((x''=y'') \times (x'\neq y')/2 + (x''\neq y'') \times (x'=y''))$$  
  $$\equiv p^2 \times (x'\neq y')/2$$  
  $$+ p \times (1-p) \times (x'=\text{head}) \times (y''=\text{tail})$$  
  $$+ (1-p) \times p \times (x'=\text{tail}) \times (y'=\text{head})$$  
  $$+ (1-p)^2 \times (x'\neq y')/2$$  
  $$\equiv (p^2 + 2p(1-p) + (1-p)^2) \times (x'\neq y') / 2$$  
  $$\equiv R$$

For the timing, just put $t:= t+1$ before the recursive call, and add timing to specification $R$:
$$R \equiv \sum x'', y'', t'': (p(x''=\text{head}) + (1-p)(x''=\text{tail})) \times (p(y''=\text{head}) + (1-p)(y''=\text{tail})) \times (t''=t) \times ((x''=y'') \times (x'\neq y') \times (t'\geq t+1) \times (p^2 + (1-p)^2) \times (t''=t') \times p \times (1-p)$$  
  $$+ (x''\neq y'') \times (x'=y'') \times (y'=y'') \times (t'=t'')$$  
  $$\equiv p^2 \times (x'\neq y') \times (t'\geq t+1) \times (p^2 + (1-p)^2) \times t'' \times p \times (1-p)$$  
  $$+ p \times (1-p) \times (x'=\text{head}) \times (y'=\text{tail}) \times (t'=t).$$
+ \((1-p)p(x'\text{=}\text{tail})\times(y'\text{=}\text{head})\times(t'=t)\)
+ \((1-p)^2x(x'\text{+}y')\times(t'\geq t+1)\times(p^2 + (1-p)^2)^{t'-t-1}\times p\times(1-p)\)
\[= \]
\((p^2 + (1-p)p)x(x'\text{+}y')\times(t'\geq t+1)\times(p^2 + (1-p)^2)^{t'-t-1}\times p\times(1-p)\)
+ \(p\times(1-p)p(x'\text{+}y')\times(t'=t)\)
\[= \]
\((x'\text{+}y')\times(t'\geq t+1)\times(p^2 + (1-p)^2)^{t'-t-1}\times p\times(1-p)\)
\[= \]
\((x'\text{+}y')\times t\times(p^2 + (1-p)^2)^{t'-t-1}\times p\times(1-p)\)

There was no need for an assumption that \(p\) differs from both 0 and 1 in either proof. But if \(p\) is either 0 or 1, the timing expression gives probability 0 to any finite value of \(t'\). And if \(p\) is either 0 or 1 we can easily prove \(t'=\infty\) (but we don't bother).

So the first program works. But the second program doesn't; it gives exactly the same result as a single flip of the coin. Here's the calculation. This time define

\[
R = \begin{cases} 
\text{if } p \text{ then } x'\text{=}\text{head} \land y'\text{=}\text{tail} & x'=\text{tail} \land y'=\text{head} \text{ fi} \\
+p\times(x'=\text{head})\times(y'=\text{tail}) + (1-p)\times(x'=\text{tail})\times(y'=\text{head}) 
\end{cases}
\]

which is a single flip, and define

\[
S = x'=x+y'
\]

then the first equation is proved as follows:

\[
\begin{align*}
\text{if } p \text{ then } x:= \text{ head else } x:= \text{ tail fi} & . \quad S \\
\text{if } p \text{ then } x:= \text{ head else } x:= \text{ tail fi}. \quad x'=x+y'
\end{align*}
\]

\[
\begin{align*}
\text{if } p \text{ then } x:= \text{ head else } x:= \text{ tail fi}. & \quad x'=x+y' \\
\text{if } p \text{ then } x'=\text{head}+y' \text{ else } x'=\text{tail}+y' \text{ fi} & \quad \text{R}
\end{align*}
\]

and the second equation is proved as follows:

\[
\begin{align*}
\text{if } p \text{ then } y:= \text{ head else } y:= \text{ tail fi}. & \quad \text{if } x=y \text{ then } x:= y. \quad S \text{ else ok fi} \\
\Sigma x', y'. & \quad (p\times(x'=x)\times(y'=\text{head}) + (1-p)\times(x'=x)\times(y'=\text{tail})) \\
& \quad \times ((x'\text{=}y')\times(x'\text{=}x')\times(y'\text{=}y') + (x'\text{=}y')\times(x'\text{=}x')\times(y'\text{=}y')) \\
& \quad \times ((x=\text{head})\times(x'=x)\times(y'=\text{head}) + (x=\text{head})\times(x'=x)\times(y'=\text{head})) \\
& \quad + (1-p)\times ((x=\text{tail})\times(x'=x)\times(y'=\text{tail}) + (x=\text{tail})\times(x'=x)\times(y'=\text{tail})) \\
& \quad p\times ((x=\text{head})\times(x'=x)\times(y'=x) + (x=\text{head})\times(x'=x)\times(y'=x)) \\
& \quad + (1-p)\times ((x=\text{tail})\times(x'=x)\times(y'=x) + (x=\text{tail})\times(x'=x)\times(y'=x)) \\
& \quad (x'=x)\times (y'\text{=}x)\times (p\times ((x=\text{head}) + (x=\text{head})) + (1-p)\times ((x=\text{tail}) + (x=\text{tail}))) \\
& \quad (x'=x)\times (y'\text{=}x)
\end{align*}
\]