

VVDQQD )LEURP 2SHQ \$FFHV



# )LEURP\DOJLD 2SHQ \$FFHV

5HVHDFK \$UWLFOH

2SHQ \$F

## 5HVHJXLHU 0HWKRG 5HGXFHV 1HXURPXVFXOD 3DUDPHWHUV LQ 3DWLHQWV ZLWK )LEURP\DOJLD

0DGGDOL %RQJL (XVSDQD.KD'GL)MIDLFH &DOLNKDQDRYD 6YHNOV0BQDR \$DQDQDH 6FLVFLROR\*LXVHSSH  
 'HSDUWPHQW RI ([SHULPHQWDO DQG &OLQLFDO 0HGLFLQH 8QLYHUVLW\ RI )ORUHQFH ,WDO\  
 \$OX55 \$VVRFLD]LRQH 0XOWLGLVFLSOLQDUH 5LDEL0LWD]LRQH 5HXPDRWR0R0JLFD ,WDO\  
 'HSDUWPHQW RI 1HXURVFLHQFH 8QLYHUVLW\ RI 3LVD ,WDO\  
 'LYLVLRQ RI 1HXURSK\VLRRJ\ &DUHJJL +RVSLWDO \$28& )ORUHQFH ,WDO\  
 &RUUHVSRRGLQDDQDORU%RQJL 6XVDQQD 'HSDUWPHQW RI ([SHULPHQWDO DQG &OLQLFDO 0HGLFLQH 8QLYHUVLW\ RI 3LVD ,WDO\  
 ,WDO\ 7HO (PDLO VXVDQQD PDGGDOLERQJL#JPDLO FRP  
 5HFHLYHG0DQW \$FFHSWHG0DWH 3XEOLVKHG GDWH 0D\  
 &RSULJKW 6XVDQQD 0% HW DO 7KLV LV DQ RSHQ DFFHVV DUWLFOH GLVWULEXWHG XQGHU WKH WH  
 XQUHVWLFWHG XVH GLVWULEXWLRQ DQG UHSURGXFWLRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO D

**\$EVWUDFW**

%DFNJURXQG DQG DLP \$FFRUGLQJ WR \$5 FULWHULD )LEURP\DOJLD 6\FKDUDFWHUL]HG E\ ZLGHVSUHDG PXVFXORVNH0HWD0 SDLQ IRU PRUH WKDQ PRQW DQG PRRG LVVXH

5HFHQW UHYLHZV VKRZ WKDW 0LQG %RG\ 7KHUDSLHV 0%7 DUH HIIHFWLYH WR 5HVVPJXLHU 0HWKRG 50 LV D 0%7 WKDW DLPV WR REWDLQ SDWLHQW QRQMXGJ 156 3DLQ DQG 5HJLRQDO 3DLQ 6FDOH±536 GLVDEL0LW\ )LEURP\DOJLD ,PSDF \$VVHVPHQW 4XHVWLRQQDLUH +\$4 KHD0WK UH0DWHG TXD0LW\ RI 0LIH 6) 'HSUHVVLQR 6FDOH +\$6 V0HHS TXD0LW\ 156 60HHS DQG IDWLJXH )XQFWLRQ 7KHUDSL\±IDWLJXH )\$&,7 I

5HVX0WV \$W EDVH0LQH ,+7 ZDV QHJDWLYH LQ )06 SWV DQG SRVLWLYH WUHDWPHQW LW UHVX0WHG QHJDWLYH LQ SWV DQG SRVLWLYH LQ LPSURYHPHQW IRU SDLQ 536 ),4 +\$4 +\$6 V0HHS TXD0LW\ )\$&,7 I 6)B 6XPPD 6XPPDU\ 3K\VLFD0 ,QGH[ 63, S IRU D00 WKH LWHPV

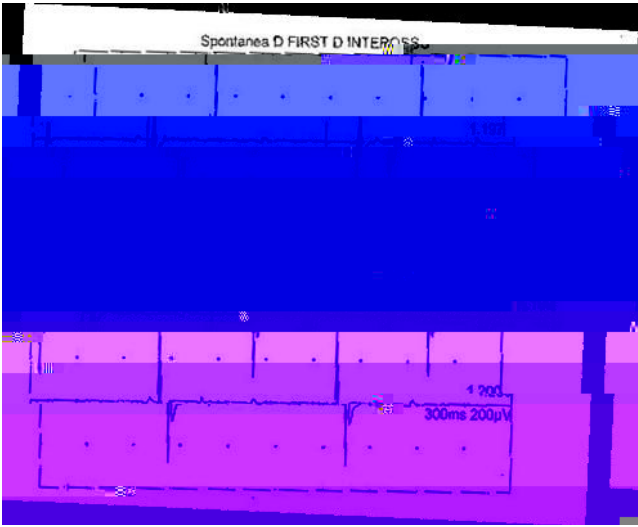
&RQFOXVLRQV :H IRXQG D KLJK SUHYD0HQFH RI 10+ LQ )06 SDWLHQWV DV DV\ HILDF\ RI 50RQ F0LQLPHWULF PHDVXUH RI )06 V\PSWRPV 0RUHRYHU ZH VKRZ DFFRUGLQJ WR RXU UHVX0WV FRXOG EH FRQVLGHUHG DV RQH RI WKH WKHUDSHXW

.H\ZRUG)LEURP\DOJLD 6\QURPH )06 ,VFKHPLD +\SHUSQHD  
 7HVW ,+7 (0HFURP\RJUDSK\ (0\* 4XD0LW\ RI /LIH 4R/  
 5HVVPJXLHU 0HWKRG 5H0DWHG 0LQG 7%RG D0WK  
 5H0DWHG 4XD0LW\ RI /LIH +54R/

### ,QWURGXFWLRQ

)LEURP\DOJLD 6\QURPH )06 LV D FRQGLWLRQ FKDUDFWHUL]HG E\ FKURQLF ZLGHVSUHDG SDLQ IRU PRUH WKDQ PRQWKV DQG RWKHU V\PSWRPV VXFK DV IDWLJXH QRQ UHVWRUDWLYH V0HHS FRJQLWL•H VVOH HDGV WR SDLQ H[DFHUEDWLRQ DQG H[FHVVLVH VHQVLWLYLW\ WR LRXV DQG QRQ QR[LRXV VWLPXOL > @

\$FFRUGLQJ WR) QK LQW HDW FHO RI )06 VKRXOG WDUJHW  
&HQWUDO 6HQVLWLYLW\ FKDQJHV ZLWK FHQWUOO\ DFWLQJ GUXJV DQG ZLWK



0DQXDO FRQWDFWV RI WKH WKHUDSLVW RQ WKH SDWLHQW HVVHQWLDO W  
SURPRWH SDWLHQW SHUHFHVS WLRQ RI

f3HVLWH J\|PQDVWLTXHg FRQVLVWLQJ RI H[HUFLVHV SHUIRUPHG GXULQJ  
WKH VHVVLRQV

k ([HUFLVHV RI FRQVFLRXV UHVSLUDWLRQ

k \$FWLYH DQG FRQVFLRXV PRYHPHQWV RI KHGG WUXQN XSSHU DQG ORZHU  
OLPUWVWQ\D VXSLQH SRVLWLRQ WKHQ VLWWLQJ DQG VWDQGLQJ  
WKHUDSLVW FKRRVHV WKH DSSURSULDWH PRYHPHQWV DQG H[HUFLVHV  
WDLORULQJ WKHP WR WKH SDWLHQW

+RPH H[HUFLVHV FRQVLVWLQJ RI WKH PRYHPHQWV RI f3HVLWH  
J\|PQDVWLTXHg FKRVLHQ E\ WKH WKHUDSLVW DQG WDLORUHG RQ WKH SDWLHQW  
DUH SHUIRUPHG GDLO\ PLQXWHV GD\ ERWK GXULQJ WKH WUHDWPHQW  
SHULRG DQG GXULQJ IROORZ XS

'DWD DQDO\VLV

**6WDWLVLWLFDO** DV **DQDO\VLV** HVVHQWHG DV 0HDQ s 6WDQGDUG  
'HYLDWLRQV 0 s 6' IRU FRQLQXRXV YDULDEOHV DQG DV QXPEHUV DQG  
SHUFHQWDJHV IRU ELQRPLDO YDULDEOHV &RQLQXRXV YDULDEOHV ZHUH WHVW  
ZLWK WKH .ROPRJRURYa6PLUQRY WHVW IRU QRUPDOLW\

'XH WR QRUPDO GLVWULEXWLRQ RI WKH GDWD VWXGHQWV 7 WHVW IRU UHSHD  
PHDVXUHV ZDV XVHG WR FRPSDUVVYDULDEOHV DW EDVHOLQH 7 HUH DQG HF6(C  
7 LQ RUGHU WR VGRVGRVW WUHDWPHQW 6366 VWDWLVLWLFDO SDFNDJH  
YHUVLRQ IRU :LQGRZV 8366 H&ZLGHV 86\$  
FRQVLVWLQJ Q3V ,&

**0LQLPDO FOLQLDOLVHQW** 0&,' LQ  
RUGHU WR TXDQWL\ LI DQ LQGLYLGXDO SDWLHQW ZLWKLQ D SDUWLFXODU WUHDW  
JURXS KDV **DLQQLDOLVHQW** DVH DQG LI LW FDQ EH XVHG WR DVVHV  
WKH PHDQ SHUFHQWDJH FKDQSHUFHQVLV WE( 7 )-9V855HQO\3-0.000061 -10.8 TD[( J)9( & , ' )-358(

'56)H 034 XWF-7(6)5(UK)2T0)/F490T130W16.95 TD[( 56)8J-76(WK)9(PW)52(W)367(F)86(H)470(LS)-5(DW)-5  
PVHU HDWPHQW)4GLQ WKHP HVI-6(X)3(V)-8(H)-5(G)-631FR HULRUPW,+7]9S  
WKHP RFLFK  
VDWYDWHPH

LQ PXVFOHV QRW FOLQLFDOO\ LQYROYHG LQ )06 > @ VXJJHVWLQJ DQ RYHUDOO  
PXVFXODU PHPEUDQH GLVRUGHU > @

,+7 PD\ GHW~~HFW~~Q~~EDG~~ D UHGXFWRQ LQ WKH WKUHVKROG RI  
H[FLWDELOLW\ RI VNHOHWDO PXVFOHV > @ RQO\ WZR VWXGLHV DQDO\]HG 10+  
LQ )06 E\ ,+7 9LWDOL HW DO VKRZHG D KLJKHU SUHYDOHQFH RI 10+ LQ  
)06 LQ FRPSDULVRQ ZLWK 5KHXPDWRLG \$UWKULWLV > @ ZKLOH %D]]LFKL HW  
DO > @ GLDJQRVHG VSDVPRSKLOLD DV D FRPRUELG DQG GLVWLQFW FRQGLWLRQ  
LQ RI )06 SDWLHQWV ,Q WKLV VWXG\ WKH GLDJQRVLV RI VSDVPRSKLOLD

WR 50 SURJUDP KV IFRPSOXHGH EH DQ XVHIXO UHKDELOLWDWLYH  
WRRO LQ )06 SDWLH QWVHSDIOWRHDYHQWLRQg ZKHQ RWKHU  
WHFKQLTXH XVHG > @

,Q WKH PDQDJHPPHQW RI )06 SDWLHQWV 0%7 DQG LQ SDUWLFXODU 50 LQ  
RUGHU WR PDLQWHDWVRXQGJEWHUWHG DW UHJXODU F\FOHV  
DQG LQWHJUDWHG LQ D PXOWLFRPSRQHQW DSSURDFK ZLWK PHGLFDO WUHDWPHQ  
DQG HGXFDWLRQDO PHDVXUHV

\$QRWKHU UHFHQW VWXG\ RYFRUV %R@DVVHVHVG WKH  
PRYHPHQW DQG SHUFHSWLRQ D PHWKRG WKDW LQWHJUDWHV 50 ZLWK ORZ  
LPSDFW H[HUFLVHVRVGHODYWHGHWKDWV VKRZHGDQ  
LPSURYHPHQW RI PDQ\ V\PSWRPV RI )06 SDLQ IDWLJXH LUULWDELOLW\  
ZHOO EHLQJ TXDOLW\ RI PRYHPHQW SRVWXUDO VHOI FRQWURO DELOLW\ WR UH  
PLQG DQG ERG\ PRYHPHQW SHUFHSWLRQ DQG WHQGHU SRLQW VFRUHV WKL  
PHWKRG LV XVHIXODZKHU SHUDRUPHQW LQ SDWLHQWV  
XQDEOH WR GHDO ZLWK VWDQGDUG WUDLQLQJ SURJUDPV

2XU VWXG\ KDV VRPH OLPLWDWLRQV VXFK DV WKH ORZ QXPEHU RI WKH  
SDWLHQWV DQG WKH DEVHQFH RI D FRQWURO JURXS DQG IROORZV XS

ULWX[LPDE LPSURYHPHQWV LQ SK\VLFDQ IXQFWLRQ RYHU \HDUV  
5KHXPDRORJ\ 2[IRUG  
:ROIH ) &ODXZ '- )LW]FKDUOHV 0\$ \*ROGHQEHUJ '/ .DW] 56 HW DO  
H